DRAFT REVISED DEVELOPMENT PLAN
FOR PUBLIC REVIEW AND COMMENT

HEBGEN LAKE ZONING DISTRICT
DEVELOPMENT PLAN

June 6, 1977

Revised and Updated January 2004

The preparation of this plan was financed, in part, through an urban planning grant from the Department of Housing and Urban Development under provisions of Section 701 of the Housing Act of 1954 as amended.

The revision and update of this plan was financed, in part, by Gallatin County, the Sonoran Institute, the Greater Yellowstone Coalition, the West Yellowstone Community Foundation, and the West Yellowstone Foundation.

CURRENT HEBGEN LAKE ZONING ADVISORY COMMITTEE
2002

David Klatt, Chairman
Dee Rothschiller
Bob Lindstrom
Gibson Bailey
Linda Blank

ORIGINAL HEBGEN LAKE ZONING ADVISORY COMMITTEE
1976

Richard W. Drew, Chairman
David Rightenour
E. L. Spainhower
Steven Trimble
Roland Whitman
Dean L. Nelson
Raymond G. Carkeek
Daniel C. McDonald
Howard A. Micklewright

Rob Klatt - Project Coordinator

GALLATIN COUNTY COMISSIONERS, 2004

John Vincent, Chairman
Bill Murdock
Jennifer Smith Mitchell

The preparation of this plan was financed, in part, through an urban planning grant from the Department of Housing and Urban Development under provisions of Section 701 of the Housing Act of 1954 as amended.

The revision and update of this plan was financed, in part, by Gallatin County, the Sonoran Institute, the Greater Yellowstone Coalition, the West Yellowstone Community Foundation, and the West Yellowstone Foundation.

f:\zone\HL\hebgen.pn

TABLE OF CONTENTS

Tables

MAPS

GOALS AND OBJECTIVES

The following goals and objectives have been developed and adopted by the Hebgen Lake Zoning District Committee in accord with this vision for the area:

The Hebgen Lake Zoning District Committee recognizes the area as a nationally known recreation area enhanced by the beauties of the natural environment. Any planning effort must relate both to the tourist industry as well as strive to protect the natural environmental qualities of the area. Planning efforts must also protect the peace and quiet enjoyed in our area's residential neighborhoods.

The committee endorses this general concept along with the following specific goals and objectives which will guide future land use and development decisions.

1. Scenic beauty and the natural environment are the greatest resources of the area and should be protected to the fullest extent possible while allowing development that is compatible with the area's natural attractions and neighboring uses.

    a. The people of the Hebgen Lake Zoning District (HLZD) support the efforts of federal land managers and conservation organizations to acquire undeveloped lands (or conservation easements on those lands) that have significant scenic and wildlife value from willing sellers in the area.

    b. Infill of existing residential subdivisions should continue at the same density permitted in the original zoning regulation.

    c. It is the hope of Hebgen Lake Zoning District Committee that private landowners will realize the special qualities and constraints of the area. Instead of using large-tract developments, we should cluster using proper planning techniques. The new zoning regulations will allow the flexibility-in-design required to accomplish this goal.

2. Protection of wildlife habitat is highly desirable.

3. Development of the Hebgen Lake shoreline should be kept to a minimum and only allowed under favorable conditions.

4. Commercial development is necessary to serve the needs of area residents and the traveling public. However, new commercial developments should be restricted to a few key locations.

    a. Strip development should not be permitted along the highways serving the HLZD.

    b. Most future commercial needs will best be served by expansion within the existing commercial zones.

    c. Signs should be kept to a minimum number and size.

5. Industrial development would degrade the natural beauty of the area and will generally be precluded. Specialized industrial activities such as batch plants, contractor storage and warehousing are associated with and are needed by local residents. These uses will be allowed on a limited basis.

6. Mobile homes, if not limited and controlled, could degrade aesthetic qualities of the area. Mobile homes should, therefore, only be allowed in designated areas and as permitted by state law.

Recreation is the over-riding use within the Hebgen Lake Zoning District and is the factor influencing the development of the area. Development of the Hebgen Lake Zoning District will distract from the quality of the environment that entices people to the area. With full or maximum development of the private land within the Hebgen Lake Zoning District, people would soon destroy the environment that they enjoy.

INTRODUCTION

Due to increased demand for recreational development in the Hebgen Lake area, including an announcement of the proposed Ski Yellowstone development, citizens in the Hebgen Lake area, during the fall of 1975, petitioned the Gallatin County Board of Commissioners to create a County Planning and Zoning District as permitted under Section 16-4100 RCM, 1947. In regard to that action, on December 3, 1975, the Gallatin County Commissioners sponsored an organizational meeting of the Hebgen Lake Zoning District at the West Yellowstone Convention Center. Various individuals, including area citizens, were invited to attend that organizational meeting.

At the meeting, the Gallatin County Commissioners appointed a zoning committee of area residents to supervise and direct the work on a proposed development pattern and accompanying zoning regulations. (See the second page of this report for a list of the original committee members.) That committee met from time to time during 1976 and discussed various goals and desires for the Hebgen Lake Zoning District. On December 15, 1976, the committee contracted with the firm of Rick Mayfield and Associates, land planners from Bozeman, to do necessary work to produce a development plan as well as accompanying zoning regulations.

Following a series of public meetings in 2000, the current Hebgen Lake Zoning Advisory Committee, county planning staff, and members of the public determined that the Hebgen Lake Zoning Development Plan and Regulations needed revision. In March 2001, the Advisory Committee launched a public process to revise the plan and regulations with the assistance of Lee Nellis, Director of Land Use Planning at the Sonoran Institute, a nonprofit organization with offices in Bozeman, MT and Tucson, AZ.

To begin the process, the Advisory Committee hosted a series of monthly educational forums for landowners in the area. Topics included:

- Discrepancies between the existing plan and code;
- Land Use Tools;
- Tools for addressing commercial development;
- Wildlife and water quality issues in the Hebgen Basin.

These educational sessions culminated in two larger public meetings during the summer of 2001 in which seasonal and long-term residents participated in a visioning exercise to identify their goals for the future of the Hebgen Basin.

Over the winter of 2001-2002, the Advisory Committee held a series of public work sessions to discuss possible changes to the regulations in order to present a workable draft for full public comment and review. During the summer and fall of 2002, the Advisory Committee sought public comment, both written and verbal, on the revisions before forwarding their recommendations to Gallatin County's Planning and Zoning Commission.

AUTHORITY

Adoption of this plan is authorized by 76–2–104, MCA, which requires that a "development pattern" be adopted for a planning and zoning district authorized by 76–2–101, MCA, et seq. This plan is the development pattern for the Hebgen Lake Zoning District.

RESOURCE INFORMATION

A vast amount of environmental research has been done for the Hebgen Lake area. For the first version of this plan, resource information included: environmental reports by Ski Yellowstone Inc. in October 1973; Hebgen Lake Planning Unit - Land Use Plan, U.S. Department of Agriculture, Forest Service; Inventory and Evaluation of Soil and Water Resources - U.S. Department of Agriculture, Soil Conservation Service; and land use studies by Gallatin County and the State of Montana Department of Community Affairs. Because of the existence of this information and because of limited funding, the 1977 plan utilized and was based on information contained in these reports.

The 2002 version of this plan was updated as necessary. This introduction and the “Population,” “Land Use,” and “Wildlife” chapters were substantially revised. New information for the updates was gathered from Montana Natural Resource Information System, Montana Department of Revenue, Montana Fish, Wildlife and Parks, Montana State University, Gallatin County, the National Park Service, and the U.S. Census Bureau. Minor changes were made in the “Soils” and “Water Resources” chapters. The “Development Plan” chapter was eliminated, with its essence being incorporated either into the “Goals and Objectives” or the “Ecological Evaluation.” The other chapters remain largely unchanged, except for editing to correct typographical errors.

In reading base information contained herein, one should remember that the original report was done for reasons other than forming a development pattern and zoning ordinance. For example, the Ski Yellowstone environmental reports were done specifically for the Red Canyon area. The Forest Service studies were done for the entire Hebgen Lake area. Nonetheless, information contained in these reports generally apply to the Hebgen Lake Zoning District. Where the information is more specific in nature than is perhaps desirable for planning purposes, mention is made of the limitations.

Much of the information in this study is quoted directly from, or partially taken from, other reports. To assure proper credit, the beginning of each section gives a brief statement of the origin of information in that section. One should realize, however, that there is a great deal of overlap in the reports that were used, making proper credit difficult. Also, it should be noted that permission to use various reports has been given by different organizations. These letters of permission are included as an appendix to this report.

LOCATION

The Hebgen Lake Zoning District is located in the extreme south of Gallatin County, immediately north of West Yellowstone and somewhat surrounding or bordering Hebgen Lake. The district encompasses approximately 20.75 square miles or 13,280 acres of land. Approximately 41 percent of that land is in private ownership with the rest being either National Forest land or covered by Hebgen Lake.

The Zoning District is almost entirely a recreational area for both local residences as well as national tourists. The area is served by two major U.S. highways, Highway 191 and Highway 287, which extends through the Zoning District.

HISTORICAL BACKGROUND

Information on history is quoted directly from the Forest Service's Hebgen Lake Planning Unit Land Use Plan. (See pages 5 and 6.)

Relics recovered within the area indicate that Native American Indians used the valley as early as 10,000 B.C. Over the years a well-used Indian trail was developed which led from the Henry's Lake area, over Targhee Pass, through the Hebgen Lake valley into Yellowstone Park, and over to the Wyoming plains. Both Bannock and Shosone Indians used this Bannock trail as recently as the late 1800's. Chief Joseph, in his historic 1877 flight from the U.S. Army, used this trail in an unsuccessful attempt to escape to Canada.

The first known white visitor to this area was a clerk of the American Fur Company, Warren Angus Ferguson. He visited the area in 1834. He named the basin "The Burnt Hole". Yellowstone Park was created in 1872, and in 1873 a wagon road was completed from Henry's Lake to the Lower Geyser Basin via Targhee Pass. At this time the West Yellowstone area was opened to homesteading. Most of the private land within the area dates back to homesteads established in that homesteading era.

In 1907, the existing railroad was completed to the west boundary of Yellowstone Park from Idaho Falls. A year later, a post office was established with the name of Riverside, Montana. A year later the town was renamed West Yellowstone. In 1911, the Gallatin Canyon was opened to summer traffic between Bozeman and West Yellowstone. The Hebgen Dam

was completed in 1914. In 1919, President Wilson withdrew 339 acres from the old Madison National Forest and created the existing town site. Lots within that town site were auctioned off in 1924 and 1929.

Commercial air service was provided in 1935 when Western Airlines began using the sod strip just west of town. The new airfield was built in 1965.

Forest Service activities within the area began in 1910 when William Race manned the Basin Ranger Station. The ranger station was moved to West Yellowstone in 1924, and then to its new quarters just outside of town in 1959.

From its inception in 1908, West Yellowstone existed primarily to serve the "100 day" tourist season in Yellowstone Park. During the winters, most people left the valley. Then in the mid-1960's the snowmobile boom began turning the town into a year-round recreation-based community. Today, the town is called the snowmobile capital of the world.

POPULATION

"Because resident population of the Hebgen Lake Zoning District is very small, especially during the winter months, a population study for the district alone would have little meaning. "

from the 1977 plan for the Hebgen Lake Zoning District

The population of the West Yellowstone Census Division, which includes the Hebgen Lake Zoning District, grew from 1,009 persons in 1970 to 2,877 in 2000, with almost half of that growth happening during the last 10 years. The division's 1990 population was 1,966.

Table 1: West Yellowston Census Division Population

Year	Population
1970	1,009
1990	1,966
2000	2,877

While the roughly 900 new residents of the West Yellowstone Census Division are only a small part of the nearly 48,000 people who moved into the Greater Yellowstone region during the 1990's, the division's 46 percent increase is faster than Gallatin County's 34 percent growth between 1990 and 2000, and much faster than the Greater Yellowstone region's overall 17 percent population gain.

Rapid as it has been, year-round population growth measures just a fraction of the pressure on the Hebgen Lake landscape. There were more seasonal homes (1,304) in the West Yellowstone Census Division in 2000 than there were year-round occupied homes (1,276). This suggests that, at peak, the "resident" population of the area could double. The number of seasonal homes has also been growing, from 1,061 in 1990 to 1,304 in 2000 (~23 percent), though not quite as rapidly as the year-round population.

Then there are the visitors. More than one million of them passed through the West Gate to Yellowstone National Park in 2001. Over the past decade, West Gate visitation has averaged 1,091,178 (roughly 36 percent of all visits to the Park). See Table 2. This flow of people has generated considerable investment in lodgings. There were approximately 1,250 lodging units and campsites available in the West Yellowstone area when the 1977 plan for the Hebgen Lake Zoning District was written. There are now just over 2,000.

Table 2: Yellowstone National Park Visitors

Year	YNP	West Entrance
01	2,758,526	1,070,493
00	2,837,000	1,142,121
99	3,131,381	1,229,076
98	3,120,830	1,192,849
97	2,889,513	1,055,372
96	3,012,171	1,116,578
95	3,125,285	1,088,230
94	3,046,645	991,712

93	2,912,193	960,922
92	3,144,405	1,064,223

SUMMARY AND CONCLUSIONS

While the year-round population of the Hebgen Lake Zoning District and the surrounding area is relatively small, it has grown rapidly in recent years. Development pressure in the area reflects not only the rapid increase in the resident population of the area, but the continuing demand for second homes and the flow of more than a million visitors a year.

LAND USE

The Hebgen Lake Zoning District is surrounded by the Gallatin National Forest and Yellowstone National Park. It also includes a large portion of Hebgen Lake. Uses in the area are generally associated or related to recreational activities. Table Three gives a general summary of land ownership within the Hebgen Lake Zoning District.

Table Three:

ACREAGE SUMMARY ***		
	Acres	**% of Total**
Private Land	5,731	36%
Forest Land	6,120	38%
Hebgen Lake	4,119	26%
Total	15,970	100%

****Note: The total acreage increased from what is listed in the 1977 plan. This is due to the increased accuracy gained from using Geographic Information System (GIS) technology to map the zoning district and all the parcels within the district. No land has actually been added to the district since the original plan was developed.*

As Table 3 shows, 36 percent of the district is private land. Of that private land, approximately 1,770 acres have been subdivided into some 763 small tracts. (See Table 4.) This represents about 31 percent of the total private land and a 96 percent increase in the area subdivided since 1977. Roughly, 47 percent of the parcels have improvements on them. Note also that approximately 1,000 acres —the Red Canyon area— were zoned for planned unit development (PUD) in 1977. While this area has not been subdivided, it has development potential with current PUD zoning. The large number of improved parcels combined with the PUD potential on the Red Canyon area means there is considerable potential for additional development in the zoning district.

Table 4:

Hebgen Lake Zoning District Parcels Summary, 2002	
Number of Parcels	972
Number of Subdivided Parcels*	763
Subdivided Acreage	1,770
Total Acreage	15,970

**Includes parcels created through a major or minor subdivision process or parcels of 20 acres or less divided by certificate of survey.*

Table 5:

Hebgen Lake Zoning District Lot Size Summary, 2002

Lot Size	Number of Parcels
Less than 1 acre	422
1 – 5 acres	300

5 – 10 acres	69
10 – 20 acres	52
20 – 40 acres	40
40 – 80 acres	20
80 – 160 acres	24
160 – 710 acres	45
Total Parcels	**972**

Table 6 shows the acreage breakdown by land classification in both 1977 and 2002 according to Gallatin County. In 1977, 35 percent of the area was classified as agriculture while only about 17 percent of the private land could be classified as developed property. In 2002, only 4 percent of the private land is classified as agriculture, while approximately 45 percent is classified as developed property, either commercial or rural residential. Forty-nine percent is classified as rural vacant, which is available for development but not yet built upon.

Table 6:

Land Classification within the Hebgen Lake Zoning District, 1977		
	Acres	**% Total**
Agriculture	1,947.47	34
Commercial	70	1
Subdivided	904.22	16
Undetermined	2,562.38	45
Total	5,484.07	96% *

**The 1977 Plan underestimated the total number of private acres in the Zoning District. These percentages were recalculated using the correct acreage in Table 7.*

Land Classification within the Hebgen Lake Zoning District, 2002		
Taxable Parcels	815	
Number of Improved Parcels	385	
Number of Vacant Parcels	430	
Percent of Improved Parcels	47%	
Land Use Classifications:	**Number of Lots:**	**Percent of Total:**
Rural Residential	323	40
Vacant Rural	398	49
Commercial	40	5
Exempt Property	11	1
Agricultural Rural (vacant agricultural)	32	4
Farmstead Rural	6	0.7
Condominium Rural	5	0.6
Total	815	100

**These figures include only taxable parcels; publicly-owned parcels and parcels without tax records are not included.*

TRANSPORTATION

The Hebgen Lake Zoning District includes two major highways, U.S. Highway 191 leading from Bozeman to West Yellowstone, and U.S. Highway 287 which is an east-west highway through the zoning district on the north side of Hebgen Lake. These two highways would be considered the connecting link between the zoning district and West Yellowstone and Yellowstone National Park.

Roads in this area have all been constructed since the 1959 Madison River Earthquake.

In 1977, winter traffic volumes on highways in the area averaged from 40 percent to 60 percent of the average daily traffic for the year. The peak load on highways occurred during the summer months, when a July weekend day averaged 2,850 vehicles traveling through the area to or from the Yellowstone Park region.

Since this plan was originally developed, traffic volumes passing through the Hebgen Lake Zoning District have risen considerably. The volume on the average July weekday was 4,411 in 2000, a 155 percent increase over a weekend day in 1977. Increasing winter visitation has raised winter traffic counts from 40 percent to 60 percent of the summer count to between nearly 60 percent to more than 70 percent of the summer count.

The majority of the private land within the zoning district is served by the two major highways, however, local access roads from the private land to the highways will continue to be necessary for any type of development within the area. There now exists a good two-lane road leading from 191 to the private land around Horse Butte and Rainbow Point. Any development of the private land in the Watkins Creek area would need to coordinate with the Forest Service since the main access is a Forest Service Road.

In 1965, a new $1,284,000 jet airport at West Yellowstone was dedicated. National Forest land was deeded to the State of Montana to make the airport possible. The National Park Service and the Federal Aviation Agency jointly financed the project. Located approximately two miles northwest of West Yellowstone, the 790-acre facility has an 8,400 foot paved and lighted runway.

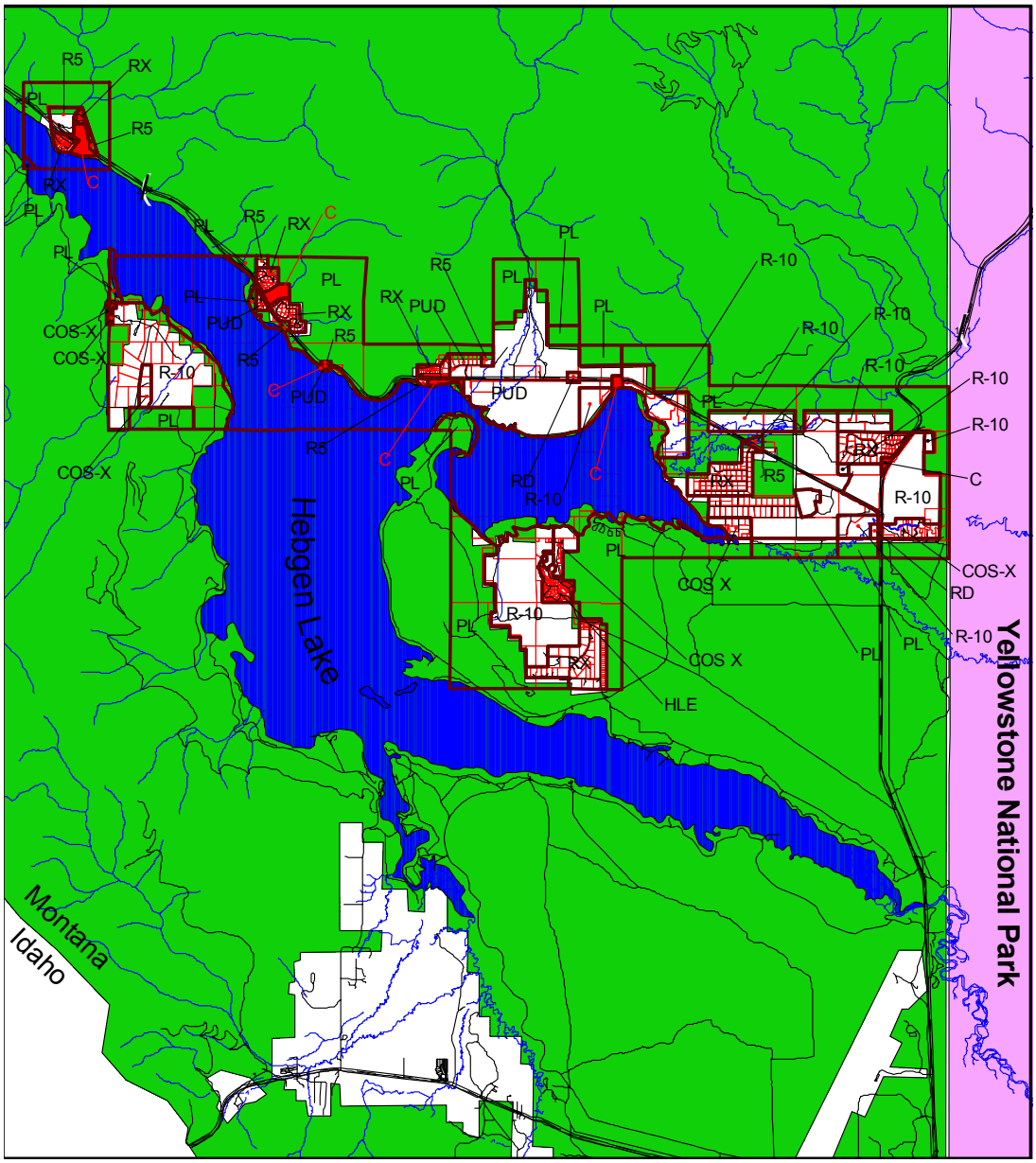
One airline, Skywest/Delta Connection, serves the West Yellowstone Airport from June 1 through September 30 each year. Private aircraft rentals and tie-down spaces are also available.

SUMMARY AND CONCLUSIONS

There have been significant changes in land use in the Hebgen District since 1977 when the district was first created, resulting from increased population and more tourist visitation in the greater West Yellowstone area. While less than half of the available parcels have been developed at this time, there is significant potential for future growth on the remaining undeveloped parcels.

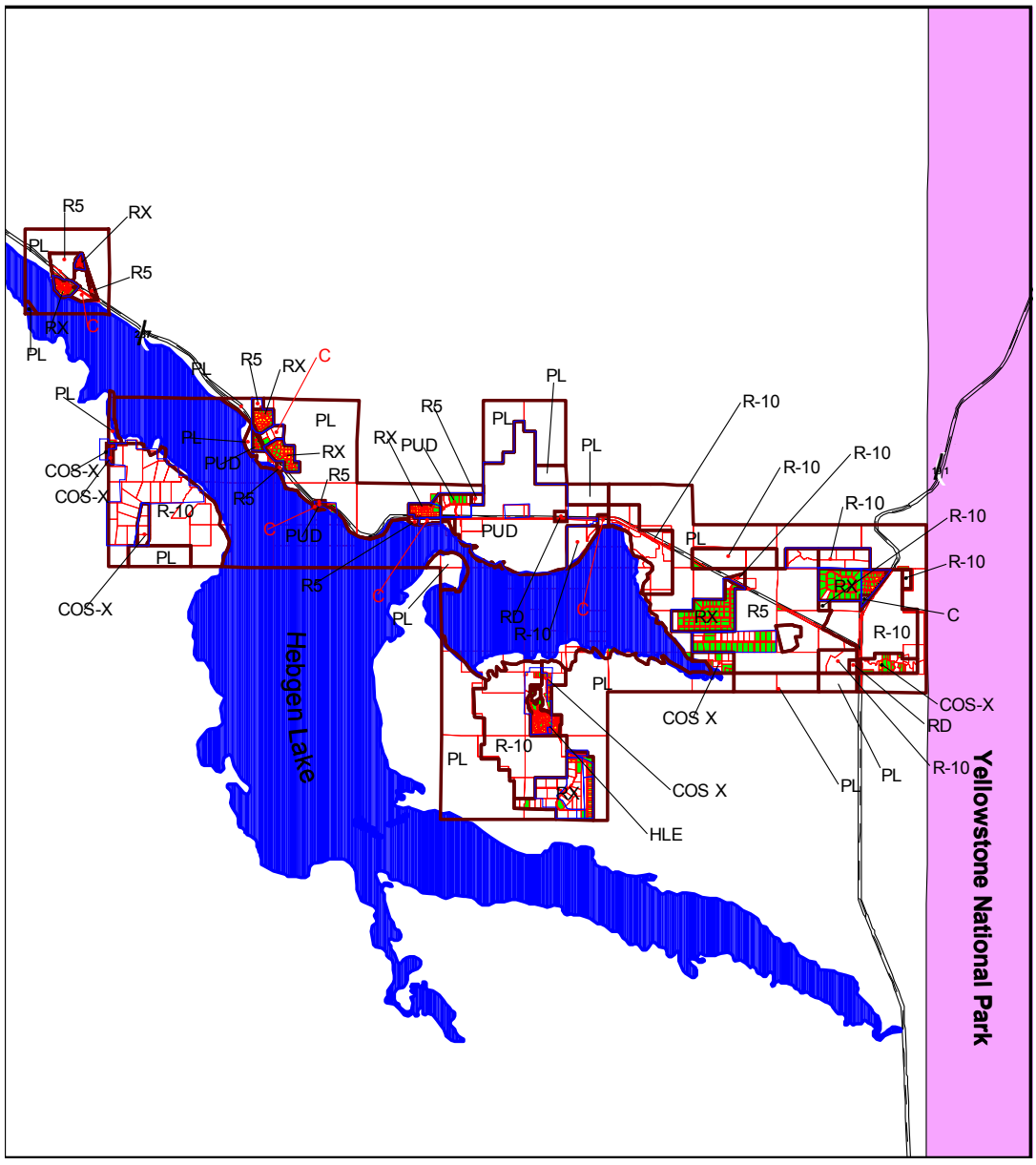
1

Hebgen Lake Zoning District and Surrounding Areas Parcels



2

Hebgen Lake Zoning District Parcels Less than 1 Acre and Parcels Between 1 Acre and 5 Acres



WEATHER AND CLIMATE

The weather and climate section of this report is quoted almost verbatim from the "Ski Yellowstone Environmental Study." The researcher was Val Mitchell. It should be noted that the weather and climate report in the Ski Yellowstone Environmental Study was done primarily for the Red Canyon area, but pertains to the entire area.

INTRODUCTION

The weather and climate of the Hebgen Lake Zoning District area contribute significantly to make the area desirable as a year-round recreation area. Summers are usually very pleasant for outdoor recreation with warm days and cool nights and little precipitation. The area is cold in winter, but not as cold as it is reputed for the area. Winter temperatures are cold enough that substantial snow fall remains on the ground throughout the winter, giving the area considerable potential for snow-based outdoor recreation.

The following is an effort to describe the weather and climate of the Hebgen Lake Zoning District in a way that is useful for the planning and development of the area. Weather data in the Hebgen Lake Zoning District is very limited, hence the data that follows are estimates for the area of interest based on knowledge of mountain meteorology and the weather records of West Yellowstone, Hebgen Dam and to a much lesser degree, Horse Butte Lookout.

TEMPERATURE

A good long-term temperature record is available for Hebgen Dam. This record provides the basis of the following discussion of temperature in the Hebgen Lake Zoning District.

In general, summers in the district are mild and winters are cold. January is the coldest month with a mean-maximum temperature of 22°F and a mean-minimum temperature of 5°F. Although the West Yellowstone-Hebgen Lake area has the reputation of being very cold in winter, these figures suggest that there are periods even during January that are pleasant and mild for winter.

The mean-maximum for July is 78°F and the mean-minimum is 46°F. Summer days tend to be very pleasant, but the nights usually are distinctly cool. There are some days during the summer when the diurnal range (the difference between the maximum temperature and the minimum temperature) is about 50°F degrees. This large temperature change from day to night should be considered in the planning of a recreational area such as Hebgen Lake.

Maximum temperatures in summer rarely exceed 90°F, but cool days when the maximum does not exceed 70°F are not uncommon, especially in August.

Winter minimum temperatures can be very cold, with a temperature occasionally reaching –40°F. However, the percent of days when these very cold temperatures occur is small. During December, January, and February, minimum temperatures of below zero can be expected about one-third of the time. Temperature inversions are quite likely when the minimum temperatures at the valley floor are below zero, with the result that it will usually be warmer in the morning on the higher slopes.

As suggested before, summer minimum temperatures can be quite cool. For example, in July and August, the minimum temperatures for about half the time can be expected to be 45°F or colder.

The duration of very cold weather is often as important as the temperature itself. While it does get very cold in the Hebgen Lake area from time to time, the cold periods are usually of short (one to three days) duration. In the 36-year period from January 1938 to February 1973, maximum temperatures of Hebgen Dam remained at or below zero for four days or more on only five occasions. The longest period of cold weather was in December 1972, when the maximum temperature remained at or below zero for eight days. This was the result of an unusually large and severe arctic outbreak that covered most of the Western United States.

The temperature estimates given are generally for the valley area of the Hebgen Lake Zoning District. These estimates cannot be realistically applied to the higher slopes such as Mount Hebgen. Although temperature information would be desirable, especially for the higher elevations, such information is unavailable and reasonable estimates cannot be made with currently existing data. The best that can be done at the present time is to present, in a very broad manner, some

general relationships between a mountain ridge or peak and the adjacent valley floor using the short term thermograph records from Mount Hebgen and the weather records from Horse Butte Lookout, which are for summers only, as guidance.

PRECIPITATION

The best estimate of the monthly and annual precipitation for the zoning district is the precipitation data from Hebgen Dam. Although the precipitation at the dam is not representative of the precipitation at higher elevations such as on Mount Hebgen, it is probably quite representative of the valley floor area. Hence, the following estimates for those lower elevations are based on the Hebgen Dam precipitation records.

The average annual precipitation for the 1931 - 1970 period is 27.41 inches. There are two rather distinct wet seasons, winter and late spring. The wettest month is June, with an average of 3.11 inches. The January precipitation is nearly as high with an average of 3.05 inches. Of the total precipitation, 48.9 percent falls during the winter (November through March) and 20.6 percent falls during May and June. The driest season of the year runs from July through September.

An important characteristic of the precipitation in the Hebgen Lake area is variability. In addition to the mean precipitation, Table 8 also presents the standard deviation of precipitation, greatest amount, and least amount for each month of the 40-year period considered. As can be seen, any month of the year can be very wet or very dry. Nine of the 12 months of the year have received more than five inches of precipitation, with the greatest total of over seven inches occurring in June and December. On the other hand, each month has had at least one occurrence of precipitation of less than one inch, with the least precipitation in August, October, and November being less than 0.1 inches during those months.

The driest year during the period considered was 1931 when only 19.44 inches of precipitation fell. The wettest year was 1964 with just over 38 inches of precipitation. It should be noted that the decade from 1961 to 1970 was considerably wetter than the preceding 30 years. Each year in this decade was wetter than the average for the preceding 30 years. During three years, 1964, 1967, and 1970, over 35 inches of annual precipitation fell. Both 1971 and 1972 were also above the long-term average.

Table 7

TEMPERATURE DATA ESTIMATES FOR HEBGEN DAM (in Fahrenheit)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max	22	28	36	47	59	68	78	77	66	52	35	24	
Min	5	6	13	25	34	40	46	44	37	27	19	8	
Mean	13.5	17.0	24.5	36.0	46.5	54.0	62.0	60.6	51.5	39.5	27.0	16.0	37.3

Table 8

PRECIPITATION DATA ESTIMATES FOR HEBGEN DAM (in inches)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	3.05	2.47	2.40	1.81	2.53	3.11	1.54	1.47	1.65	1.84	2.54	2.94	27.41
Std. Dev.	1.44	1.06	1.22	.97	1.26	1.54	.89	1.28	1.22	1.28	1.16	1.31	5.06
Greatest	6.90	5.33	5.06	4.50	6.02	7.50	3.86	6.28	5.42	6.22	4.80	7.10	38.06
Least	.66	.66	.52	.31	.16	.67	.30	.06	.13	0	.08	.90	19.44

Table 8

ESTIMATED AVERAGE NUMBER OF DAYS WITH MEASURABLE PRECIPITATION

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
17	12	11	9	11	13	7	7	8	7	12	15	129

SOILS

The information contained in this section is taken directly from a U.S. Department of Agriculture Soil Conservation Service report entitled “Inventory and Evaluation of Soil and Water Resources, Hebgen Lake Planning District” (March 4, 1977). Chart 14, however, is only a part of the soil interpretation tables contained within that report. For planning purposes in the Hebgen Lake Zoning District, only those uses considered to be the greatest factor in development of the district are used in this report. For a complete listing of other uses, the reader is referred to the Soil Conservation Service study.

SOIL MAPPING UNIT DESCRIPTIONS

1B This moderately deep, well-drained soil is on terraces and fans with slopes of 2 to 4 percent. The typical profile has a very dark gray, gravelly loam surface layer about six inches thick. The subsoil is brown, gravelly loam about 14 inches thick. The underlying material is light gray, gravelly loam to a depth of about 34 inches with sand, gravel and cobbles below.

Estimated permeability is moderate, 0.6 to 2.0 inches per hour, in the upper 34 inches of the soil and rapid, 6.0 to 20.0 inches per hour, below.

Important inclusions are numerous. The inclusions are old drainage channels, small areas with very gravelly or cobbly surface layers and areas where the rapidly permeable substratum is at depths of 15 to 20 inches.

Land capability subclass: IVe, Silty Range Site.

2C This moderately deep, well-drained soil is on terraces and fans with slopes ranging from 2 to 8 percent. The typical profile has a black, gravelly loam surface layer about twelve inches thick. The subsoil is dark brown, gravelly sandy loam to about 36 inches and the underlying material is sand and gravel.

Estimated permeability is moderate, 0.6 to 2.0 inches per hour, in the upper 36 inches of the soil and rapid, 6.0 to 20.0 inches per hour, below.

Small areas of important inclusions are poorly-drained swales and drainways; and soil with very gravelly or cobbly surface layers.

Land capability subclass: IVe, Silty Range Site.

3AB This moderately deep, well-drained soil is on terraces and fans with slopes of 0 to 4 percent. The typical profile has a very dark brown, clay loam surface layer about six inches thick. The subsoil is brown clay loam about 10 inches thick. The underlying material to about 24 inches is gravelly loam with very gravelly sand below.

Estimated permeability is moderately slow, 0.2 to 0.6 inches per hour, in the upper 24 inches and rapid below, 6.0 to 20.0 inches per hour.

Important conclusions are areas with gravelly surface layers and, small poorly-drained swales and drainage ways.

Land capability subclass: IV, Clayey Range Site.

4A This is a complex of poorly-drained and very poorly-drained soil on low stream terraces and swales. Slopes are mainly less than 2 percent. The soils are deep and moderately deep. They are mainly loam and clay loam in texture and have slow to moderate permeability, 0.06 to 2.0 inches per hour.

Most of the soils have a water table of 24 inches at some time of the year, but it fluctuates to as deep as 60 inches, usually during fall and winter. Many areas occasionally flood. In some areas, the wetness is aggravated by irrigation diversions.

Important inclusions are small areas of organic soils, a few areas that are well-drained and some that are shallow to loose sand and gravel.

Land capability subclass: Vw, Subirrigated and Wetland Range Sites.

5A This very poorly-drained, organic soil occurs in basins and low gradient drainage ways. The typical profile has two to four feet of mainly fibrous peat over stratified alluvium.

The water table is at or near the surface most of the year. The vegetation is mainly sedges, rushes and willows.

Important inclusions are small areas of sandy to clayey, poorly-drained mineral soils

Land capability subclass: VIw, Wetland Range Site.

6AB This shallow poorly-drained soil occurs on low stream terraces and fans with slopes of 0 to 4 percent. The typical profile has a very dark gray, sandy loam surface layer about six inches thick. The subsoil is gravelly sandy loam about 12 inches thick. The underlying material is very gravelly sand, extending to 60 inches or more.

The water table is within 36 inches of the surface at some time of the year. In some areas, the water table drops to below 60 inches at some time during the year, mainly late fall and winter. Permeability is moderately rapid, 2.0 to 6.0 inches per hour in the upper 18 inches and rapid, 6.0 to 20.0 inches per hour, below. Water drains freely from the soil as the water table lowers.

Important inclusions are small areas of deep, slowly permeable soils and very poorly-drained, organic soils.

Land capability subclass: Vw, Subirrigated Range Site.

7D This deep, well-drained soil is on footslopes with gradients of 8 to 15 percent. The typical profile has a dark grayish brown, cobbly loam surface layer about five inches thick. The subsoil is brown, cobbly loam about 10 inches thick. The underlying material to 60 inches is light gray, moderately alkaline, stony loam containing from 30 to 60 percent by volume of gravel, cobbles and stones.

Estimated permeability is moderate, 0.6 to 2.0 inches per hour, in the upper 30 inches; and moderate or moderately rapid, 0.6 to 6.0 inches per hour, below.

Important inclusions are a few small areas having stones in the surface layer.

Land capability subclass: VIe, Silty Range Site.

8E This deep, well-drained soil is on footslopes and mountain sides with slopes of 15 to 35 percent. The typical profile has a very dark grayish brown, stony loam surface layer about five inches thick. The subsoil is pale brown, stony loam that is about 10 inches thick. The underlying material which goes down to 60 inches is light gray, moderately alkaline, stony loam containing from 30 to 60 percent by volume of gravel, cobbles and stones.

Estimated permeability is moderate, 0.6 to 2.0 inches per hour. These hilly and steep soils are commonly unstable and subject to mass movement.

Important inclusions are small areas with deep black soils, areas with greater or lesser slopes, and in a few places, some soils with slowly permeable, clay loam subsoil.

Land capability subclass: Ive, Silty Range Site.

9AB This shallow, somewhat excessively drained soil is on terraces and fans with slopes of 0 to 4 percent. The typical profile has a very dark brown, gravelly sandy loam surface layer about five inches thick. The subsoil is dark brown, gravelly sandy loam about twelve inches thick. The underlying material is very gravelly, loamy sand, which goes down to 60 inches or more. In places, the gravel is mainly less than one inch in diameter; but cobbles and large gravel may also occur in the profile.

Estimated permeability is moderately rapid, 2.0 to 6.0 inches per hour, in the upper 17 inches and rapid, 6.0 to 20.0 inches per hour, below.

9AB, Continued Important inclusions are short, steep terrace edges and small, poorly-drained, swales and narrow areas bordering lakes and streams.

Land capability subclass: IVe, Shallow Range Site.

10A This shallow, somewhat excessively drained soil is on terraces and fans with slopes mainly less than 2 percent. The typical profile in woodland has about one inch of forest litter on the surface. The mineral surface layer is very dark grayish brown, fine gravelly sandy loam about two inches thick. The subsoil is brown, fine gravelly sandy loam about 16 inches thick. The underlying material that goes to 60 inches or more is fine, very gravelly sand. The gravel and sand is mainly volcanic cinders and obsidian and it occurs at a depth of 15 to 28 inches.

Estimated permeability is moderately rapid, 2.0 to 6.0 inches per hour down to 18 inches; and rapid, 6.0 to 20.0 inches per hour, below. A few areas have grass, shrub, and forb cover rather than trees.

Important inclusions are short, steep terrace edges; and small, poorly-drained swales and narrow areas bordering lakes and streams.

Land capability subclass: IVs, Woodland Range Site.

11CD This deep, well-drained soil on rolling glacial till deposits with complex slopes of four to 15 inches thick. The subsoil is brown, friable clay loam and is about 30 inches thick. The substratum is pale brown, gravel loam to 60 inches deep. Estimated permeability is moderate, 0.6 to 2.0 inches per hour.

Land capability subclass: Ivs, Woodland Range Site.

12E This deep, well-drained soil is on hilly and steep glacial deposits with complex slopes ranging from 15 to 35 percent. The typical profile has a very dark brown, stony loam surface layer about 10 inches thick. The subsoil is brown, friable clay loam about 20 inches thick The underlying material to a depth of 60 inches is pale brown, gravelly loam. Estimated permeability is moderate, 0.6 to 2.0 inches per hour.

Important inclusions are small areas of deep black loam soil and small areas with slopes of less than 15 percent.

Land capability subclass; VIe, Silty Range Site.

13E This deep, well-drained soil is on mountain slopes and hilly glacial deposits with slopes of 15 to 35 percent. The typical profile in woodland has a thin, organic layer of raw and partly decomposed forest litter. The mineral surface layer is grayish brown, angular, cobbly, sandy loam about 10 inches thick. The underlying material to a depth of 60 inches is pale brown, sandy loam, or loam containing from 30 to 70 percent angular, gravel, cobbles, and stone.

Estimated permeability is moderate, 0.6 to 2.0 inches per hour, in the upper 40 inches and moderate to moderately rapid, 0.6 to 6.0 inches per hour, below. A few areas have grass cover.

Important inclusions are small areas with slopes less than 15 percent poorly-drained drains and seeps, and spots with stones on the surface.

Land capability subclass; VIe, Woodland Site.

14E This complex of soils occurs on mountain sides with slopes ranging from 15 to 35 percent. The soils are mainly dark colored loams, differing mainly in the depth to sandstone, volcanic tuff, or limestone bedrock. About 60 percent is moderately deep 20 to 40 inches thick, black soil with few coarse fragments; 15 percent is shallow, 10 to 20 inches thick, soil with many stones and cobbles; and about 5 percent is nearly barren rock outcrops.

The estimated permeability of these soils is moderate, 0.6 to 2.0 inches per hour. Bedrock is the main limiting feature.

Important inclusions are small areas of clayey soil and shale bedrock, and some short, very steep slopes.

Land capability subclass: VIe, Silty and Shallow Range Sites.

15BC This deep, well-drained soil is on fans, footslopes and terraces with slopes of 2 to 8 percent. The typical profile has a black loam surface layer about 20 inches thick. The subsoil is pale brown loam to about 40 inches and light gray loam or clay loam below.

Estimated permeability is moderate, 0.6 to 2.0 inches per hour. Important inclusions are small seeps and narrow drainage ways.

Land capability subclass: IVe, Silty Range Site.

16BC This deep, well-drained soil is on fans and terraces with slopes of 2 to 8 percent. The surface layer is dark reddish brown loam about 24 inches thick. The underlying material is reddish brown, gravelly loam or light clay loam extending to about 60 inches.

Estimated permeability is 0.6 to 2.0 inches per hour.

Important small inclusions are areas with gravelly or stony surface layers and narrow stream channels.

Land capability subclass: IVe, Silty Range Site.

17E This deep, well-drained soil is on fans, foot slopes and hillsides with slopes of 15 to 35 percent. Typically the surface layer is black loam about 20 inches thick; but in many places, there are some areas that have stones on the surface. The subsoil at 60 inches is pale brown loam or light clay loam containing from 10 to 30 percent of gravel, cobbles and stones.

Estimated permeability is moderate, 0.6 to 2.0 inches per hour.

Important inclusions in this soil are small areas where bedrock either outcrops or is near the surface of the soil.

Land capability subclass: VIe, Silty Range Site.

19B This deep, well-drained soil is on glacial terraces with slopes of 2 to 4 percent. The typical profile has a dark brown loam surface layer about 20 inches thick. The subsoil is reddish brown, gravelly clay about 15 inches thick. The underlying material is gravelly clay loam with a few cobbles and stones to a depth of sixty inches.

Estimated permeability is slow, 0.06 to 0.20 inches per hour. There is some variation in the coarseness and permeability of the materials below about 36 inches.

Land capability subclass: IVe, Silty Range Site.

20D This deep, well-drained soil is on footslopes and land flows with complex slopes of mainly 8 to 15 percent. The typical profile has a black heavy loam surface layer about 10 inches thick. The subsoil is dark brown clay about 15 inches thick. The underlying material is stratified clay loam and clay containing from 10 to 30 percent by volume of gravel, cobbles and stones.

Estimated permeability is slow, 0.06 to 0.2 inches per hour. These hilly and steep soils are unstable and subject to mass movement.

Important inclusions are small, wet closed basins; seeps; very stony spots; and short, steep slopes.

Land capability subclass: VIe, Silty Range Site.

INTERPRETATIONS OF SOILS

Interpretations are given in the following charts for a number of alternative uses. The ratings used are for the main soils in the mapping unit and may not apply to minor included soils included within the mapping unit. More than one rating is given where soil properties overlap the rating criteria. The interpretations can, however, be useful in general land use planning, in assessing hazards and development problems, in comparing different areas for specific use and in planning more detailed investigations at selected sites. Interpretations are based on the upper five feet of soil material in its natural state.

In the interpretation charts, each soil is considered for the uses that may reasonably apply. For some of the uses, soil limitations are indicated by the ratings slight, moderate, and severe. Slight means soil properties generally are favorable for the use or, in other words, limitations are minor and easily overcome. Moderate means that some soil properties are unfavorable, but can be overcome or modified by special planning and design. Severe means soil properties are so unfavorable and difficult that to correct or overcome them requires major soil reclamation or special design. For other uses, such as topsoil, suitability is rated by the terms good, fair, and poor, which have meanings approximately parallel to the terms slight, moderate and severe. For other uses, no rating is given but important soil features to be considered in planning, installation or maintenance are listed. Where ratings of moderate, fair, severe, or poor are used, the main limiting features are given.

Following are explanations of the selected uses listed in the interpretation table:

Sanitary Facilities
Septic tank absorption fields are subsurface systems of tile of perforated pipe that distribute effluent from a septic tank into natural soil. The soil material from a depth of 24 inches to 60 inches is evaluated. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, depth to water table or rock, and susceptibility to flooding. Soil properties are considered that affect the pond floor are permeability, organic matter and slope. The soil properties that affect the embankment material that influence the ease of excavation and compaction are also considered.

Sanitary Landfill
Trench type, is a method of disposing of refuse in dug trenches. The waste is spread in thin layers, compacted, and covered with soil throughout the disposal period. Landfill areas are subject to heavy vehicular traffic. Some soil properties that affect suitability for landfill are ease of excavation, hazard of polluting ground water, and the ability to handle a large volume of traffic. The best soils have moderately slow permeability, withstand heavy traffic, and are friable and easy to excavate. Ratings apply only to a depth of about five feet, and therefore limitation ratings of slight, or moderate may not be valid if trenches are to be much deeper than that.

For some soils, reliable predictions can be made to a depth of 10 to 15 feet, but regardless of that, every site should be investigated before it is selected. Ratings are also given for area-type landfills, and for use as cover material. In area-type landfills, refuse is placed on the surface of the soil in successive layers and covered daily with material excavated from another source.

Dwellings
Dwellings, for which the soils are given limitation ratings, are those not more than three stories high and that are supported by foundation footings placed in undisturbed soil. The features that affect the rating of a soil for such dwellings are those that relate to capacity to support load and resist settlement under load. Soil properties that affect capacity to support load are wetness, susceptibility to flooding, density, plasticity and texture.

Local Roads and Streets
Local roads or streets for which ratings are given, have an all-weather surface expected to carry automobile traffic all year. They have subgrade of underlying soil material; a base consisting of gravel, crushed rock or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. These roads are graded to shed water and have ordinary provisions for drainage. They are built mainly from soil at hand, and most cuts and fills are less than six feet deep.

Soil properties that most affect design and construction of roads and streets are load-supporting capacity and stability of the subgrade, and the workability and quantity of cut and fill material available. The shrink-swell potential indicates traffic supporting capacity. Wetness and flooding affect stability of the material. Slope, depth to hard rock, content of stones and rocks, and wetness affect ease of excavation and amount of cut and fill needed to reach an even grade.

Topsoil
Topsoil is used for dressing the surface of an area where vegetation is to be established and maintained. Suitability is affected mainly by ease of working and spreading the soil material, for preparing a seedbed, natural fertility of the material, the response of plants when fertilizer is applied; and absence of substances toxic to plants. Texture of the soil material and its content of stone fragments are characteristics that affect suitability, but also considered in the rating is the damage that will result in the area from which topsoil is taken.

Soils and Recreational Developments:

Camp Area
These are areas to be used intensively for tents and small camp trailers and the accompanying activities of outdoor living. It is assumed that little site preparation will be done other than shaping or leveling for tents and parking areas. Soils should be suitable for heavy foot traffic and limited vehicular traffic. Suitability for growing vegetation is an important consideration.

Picnic Areas
These are park-type picnic areas. It is assumed that most vehicular traffic is confined to access roads. Suitability for growing vegetation is an important consideration.

Playgrounds
Playgrounds are areas to be used intensively for baseball, football, badminton, and for other similar organized games. These areas are subject to intensive foot traffic. A nearly level surface, good drainage, and a soil texture and consistency that give a firm surface generally are required. The most desirable soils are free of rock outcrops and coarse fragments. Soil suitability for growing vegetation is an important consideration.

Paths and Trails
Paths and trails include local and cross-country footpaths, trails and bridle paths. It is assumed that these areas will be used as they occur in nature and that little or no soil will be moved (excavated or filled). Soil features that affect the ability to handle high-volume traffic, dust, design and maintenance are given special emphasis. These include soil texture, wetness, slope and coarse fragments.

SUMMARY AND CONCLUSIONS

Soils interpretations, as listed on Table 14, are mapped for illustrative purposes on the following five soil limitations maps. In reviewing those maps, the reader should realize that most soils limitations can be overcome, but doing so usually results in more expense to the developer. There are exceptions to this rule, the most critical of which is that structures should generally be prohibited where there is a high water table.

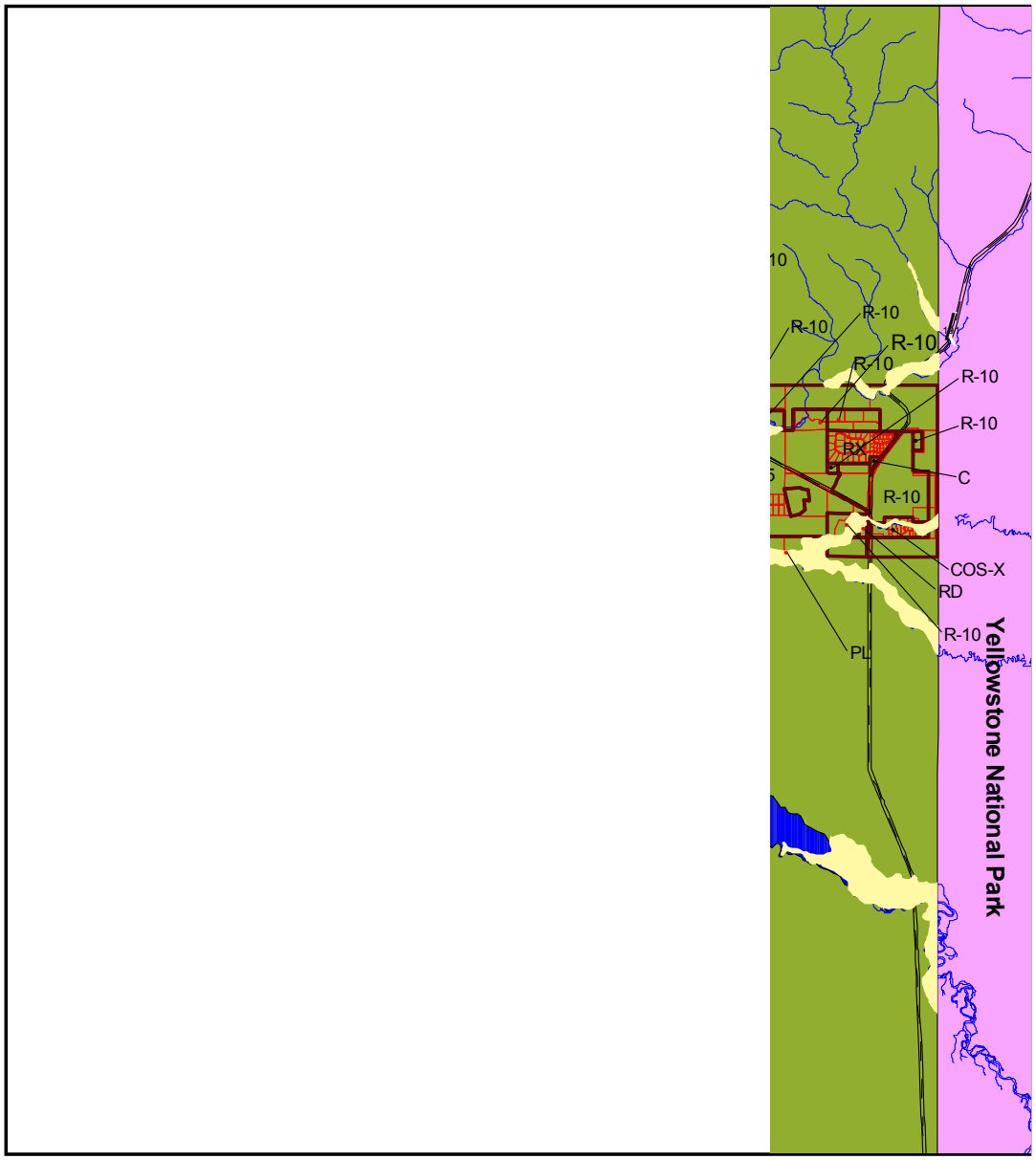
In reviewing the soil survey map and data, attention should be given to the fact that there is a severe limitation on the installation of conventional septic tank disposal systems and excavations in a large portion of the Hebgen Lake Zoning District. Note also that the definitions used by the Natural Resources Conservation Service in mapping soils limitations have changed since 1977. The limitation on the installation of septic tank absorption fields in soil mapping units 1B, 3AB, 9AB, 10A is now “severe.”

This update of the plan has added maps specifically showing the areas in the HLZD which have a high water table and where there are rapidly permeable soils. (See Maps 9 and 10.) Some of these areas are also subject to flooding, and we have provided a map of seasonal flood hazards. (See Map 11.) Development should avoid areas where a high water table, rapidly permeable soils, and seasonal flood hazards combine. Not only are these areas where on-site sewage disposal can lead to groundwater contamination, they are also the most important wildlife habitat in the HLZD.

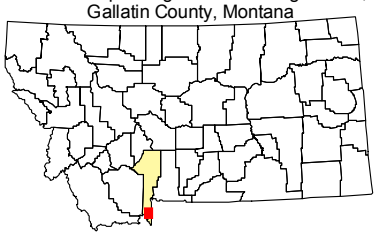
In general, the soil limitations maps speak for themselves in illustrating soil limitations for man-made developments. It should be realized in looking at these maps, however, that even though certain areas are marked severe, the areas differ in soil type and, therefore, differ in reasons for the ranking of severe. Also, it should be realized that these soil limitations are from a general soil study and that developers should be required to complete more detailed soil studies.

In addition, it would benefit the water quality of the district if the Gallatin Health Department made a final inspection of each sewer installation.

Hebgen Lake Zoning District and Surrounding Areas Depth to High Water Table

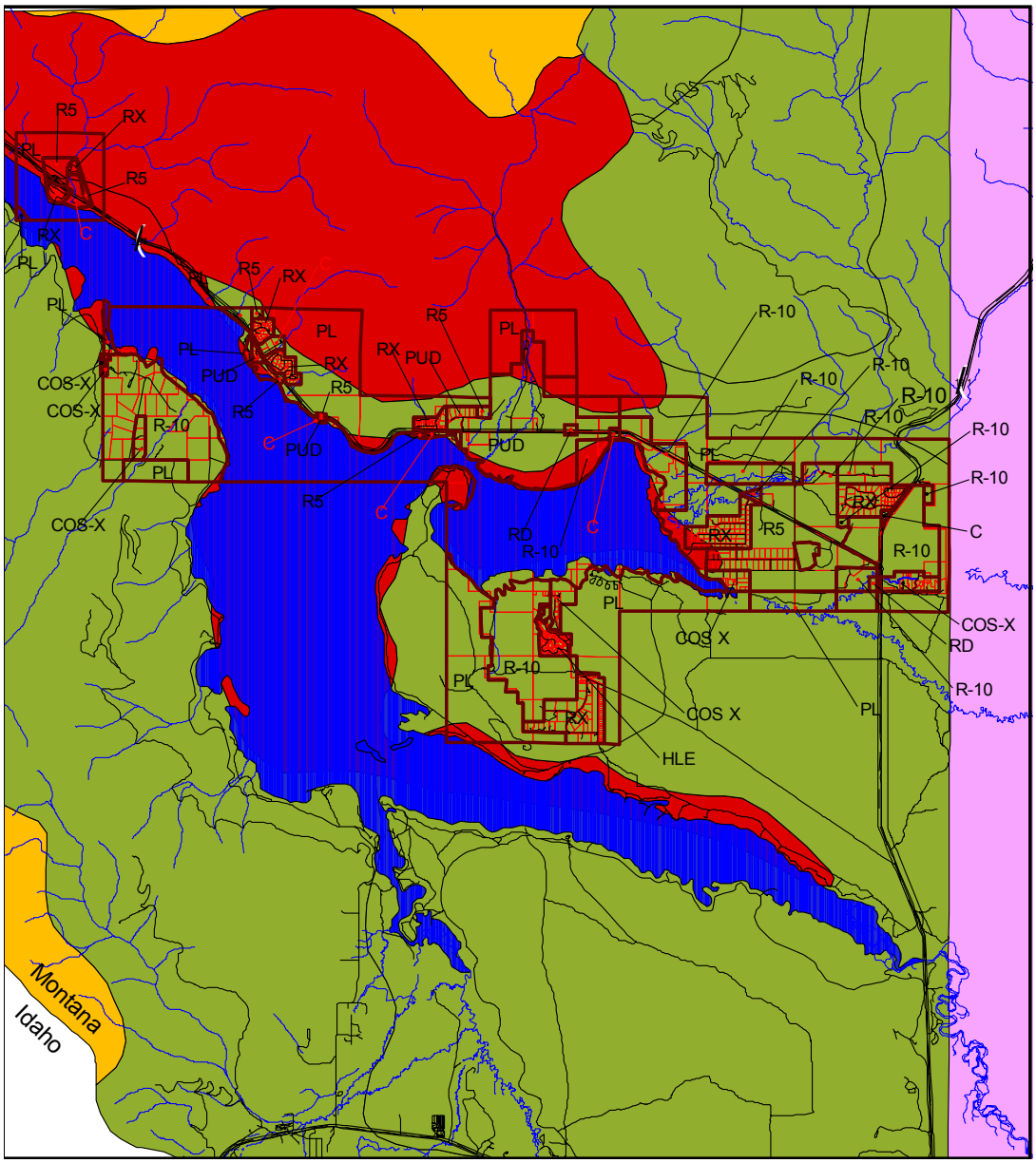


Location Map: Hebgen Lake Zoning District, Gallatin County, Montana



o 10

Hebgen Lake Zoning District and Surrounding Areas Soil Permeability



11

Hebgen Lake Zoning District and Surrounding Areas Flooding

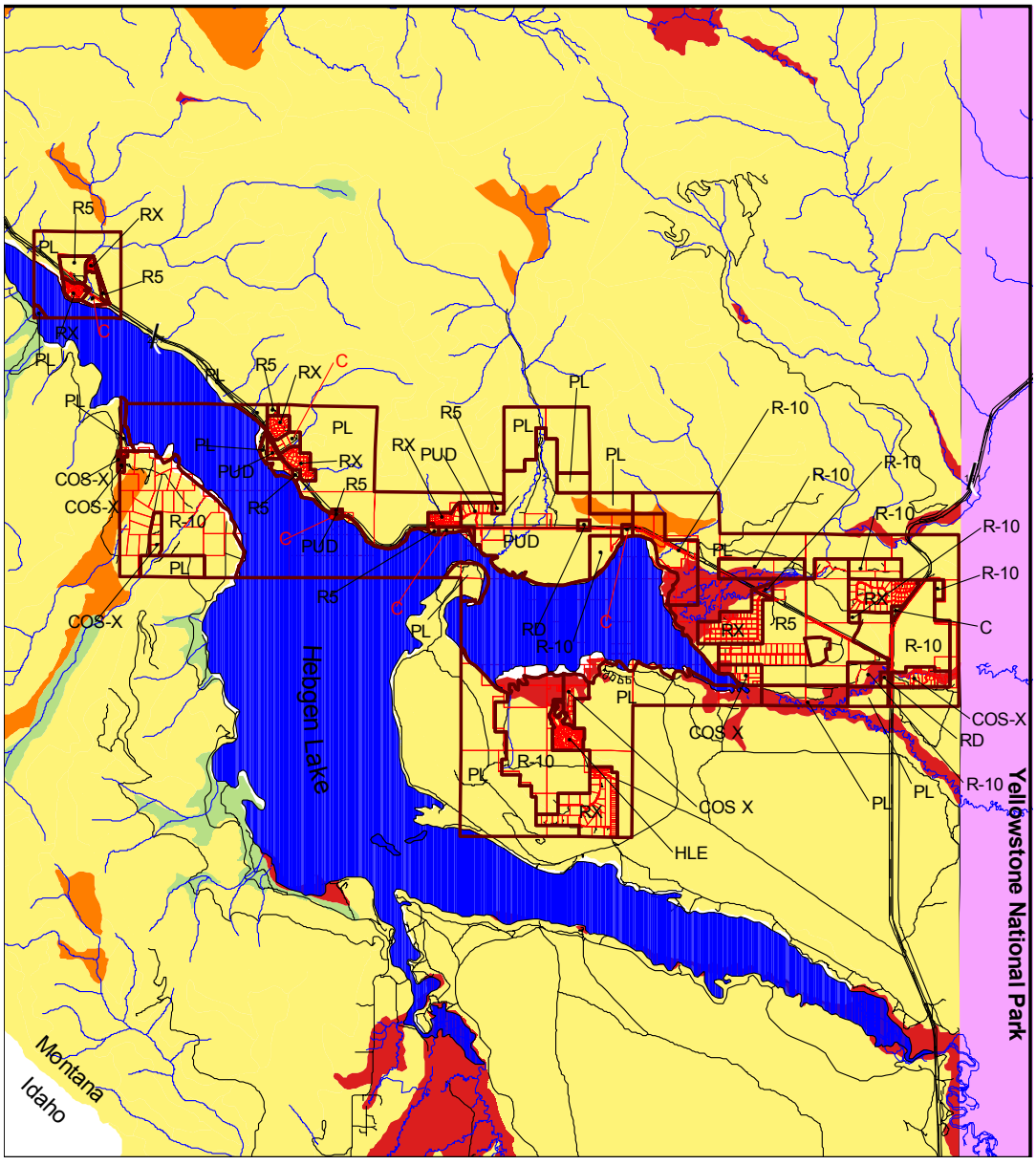


Table 10:

SOIL INTERPRETATIONS					
DWELLINGS					
SOIL GROUP	WITHOUT BASEMENTS	WITH BASEMENTS	LOCAL ROADS AND STREETS	SEPTIC TANK ABSORPTION FIELDS	EXCAVATIONS
1B	Slight	Slight	Moderate - Frost Action	Slight 1/	Severe - Cutbank Cave
2C	Slight	Slight	Moderate - Frost Action	Moderate - Percs Slowly	Severe - Cutbank Cave
3AB	Slight	Slight	Moderate - Frost Action	Slight 1/	Severe - Cutbank Cave
4A	Severe - Floods, Wetness	Severe - Floods, Wetness	Severe - Floods	Severe - Wetness	Severe - Floods, Wetness
5A	Severe - Wetness, Low Strength	Severe - Wetness, Low Strength	Severe - Wetness, Low Strength	Severe - Floods, Wetness	Severe - Wetness Low Strength
6AB	Moderate - Wetness	Severe – Wetness	Moderate - Wetness	Severe - Wetness 2/	Severe - Cutbank Cave, Wetness
7D	Moderate - Slope, Large Stones	Moderate - Slope, Large Stones	Moderate - Slope, Large Stones	Moderate - Slope Large Stones, Percs Slowly	Moderate - Slope Large Stones
8E	Severe - Slope	Severe – Slope	Severe - Slope	Severe - Slope	Severe - Slope
9AB	Slight	Slight	Moderate - Frost Acon	Slight 1/	Severe - Cutbank Cave

1/ Potential Ground Water Pollution Hazard
*2/ Some Areas Subject to Flooding

Table 10 continued:

DWELLINGS					
SOIL GROUP	WITHOUT BASEMENTS	WITH BASEMENTS	LOCAL ROADS AND STREETS	SEPTIC TANK ABSORPTION FIELDS	EXCAVATIONS
10A	Slight	Slight	Moderate-Frost	Slight 1/	Severe - Cutbanks Cave
11CD	4-8% : Slight 8+% : Moderate, Slope	4-8% : Slight 8+% : Moderate, Slope	Moderate - Slope, Frost Action	Moderate - Percs Slowly, Slope	4-8% : Slight 8+% : Moderate Slope
12E	Severe - Slope	Severe - Slope	Severe - Slope	Severe - Slope	Severe - Slope
13E	Severe - Slope	Severe - Slope	Severe - Slope	Severe - Slope	Severe - Slope
14E	Severe - Slope	Severe - Slope, Depth to Rock	Severe - Slope	Severe - Slope, Depth to Rock	Severe - Slope Depth to Rock
15BC	Slight	Slight	Moderate - Frost Action	Moderate - Percs Slowly	Slight
16BC	Moderate - Low Strength	Moderate - Low Strength	Moderate - Frost Action	Moderate - Percs Slowly	Slight
17E	Severe - Slope	Severe - Slope	Severe-Slope	Severe-Slope	Severe - Slope
18B	Moderate - Shrink Swell	Moderate - Shrink Swell	Moderate - Frost Action	Severe - Percs Slowly	Severe - Too Clayey
19B	Moderate - Shrink Swell	Moderate - Shrink Swell	Moderate - Frost Action, Low Strength	Severe - Percs Slowly	Moderate - Too Clayey
20D	Severe - Land Flow	Severe - Land Flow	Moderate - Slope, Frost Action	Severe - Percs Slowly	Moderate - Slope

GEOLOGY

The purpose of this section is not to give a detailed description of the geology or the geological conditions of the Hebgen Lake Zoning District, but rather to give an overview of some of the geological conditions and some of the geological limitations of the district as related to possible developments.

Source information for this section is primarily the Applied Geology Section of the Ski Yellowstone Environmental Study - October 1973 authored by John Montagne and Robert Page. In fact, the majority of this section is quoted from the study.

STRUCTURAL GEOLOGY

Structural geology holds important keys to the geological behavior of the Red Canyon area and it must be strongly considered in any man-oriented activity. For true understanding, it is necessary to consider the past geological history because recent events, such as the Hebgen Earthquake of 1959, owe many of their characteristics to the imprint of the past.

Two events prior to the most recent few millions of years stand out; they are the structure created in the Precambrian basement rocks over a billion years ago, and the Laramide mountain building episode (i.e. orogeny) of 50 to 66 million years ago. Of the former we know very little . . . Foliation planes were created in the rocks, and probably the basement rocks were folded if not faulted in conjunction with, or later than the metamorphism that created the foliation. Foliation, as we see it today, is measurable, and can be mapped like strata in sedimentary rocks.

The second event of importance was the Laramide orogeny. Its characteristics are well known throughout the Rocky Mountain region and more or less of similar nature throughout the region. Basically, the Laramide was a compressional episode. The Earth's crust with its relatively thin skin was shortened and compressed into giant wavy masses. At Hebgen Lake, as in most other similar localities, the folds eventually were overturned along their limbs and ruptured in response to continued stress, as thrust faults allowed rocks to be pushed one over the other.

According to Witkind, et. al. (1964, Laramide compression moved the Madison Range block northeastward along a northwest trending lineament that passes along the north edge of Hebgen Lake. This northwest lineament conforms with many similarly oriented lineaments in this part of Montana. More locally, the compressional zone in the Red Canyon area takes the form of two thrust faulted anticlinal ridges. Hebgen Ridge, as outlined by Witkind, extends northeastward as far as Dave Johnson Creek, and involves both the Wells and Johnson thrust faults. The locus of distortion and rupture northeast of the mouth of Dave Johnson Creek skips northeastward to Kirkwood Ridge, whose north bounding thrust passes two miles to the east of Red Canyon fan where it becomes covered by landslides and late age rhyolitic lava.

These structures set the stage for further modification of the area. Common to the history of the Rockies, and many other ranges in the world as well, an episode of post-compressional block faulting was brought about by tensional forces late in the regional orogenic history. Although the origin of tensional forces of this type is not clearly understood, one rather feasible explanation refers to regional upwelling of broad parts of mountainous compressional forces where relaxed. Whatever the true explanation, we do know that tensional faults accompanied the regional uplifts, and at Hebgen these tensional faults have been active for at least several million years.

The Hebgen Fault is a tensional fault that bounds (and now forms) the southwest face of Hebgen Ridge. The fault is as close as a thousand feet southwest of the Johnson Thrust, and tends to die out a mile or so north of Dave Johnson Creek. The other important tensional fault in the Red Canyon area is the Red Canyon Fault, which displays relations similar to those of the Hebgen Fault, but which forms the southwest margin of Kirkwood Ridge. Both faults dip generally southwestward at about 75 degrees, and both tend to exploit previous weakness zones such as the planes of more ancient thrust faults and the steeply dipping shaley units on the upright southwest limbs of anticlines created during the compressional phase of folding. In the case of Kirkwood Ridge, the tensional Red Canyon Fault is located along the shaley part of the Amsden Formation for a good part of its length.

The 1959 movements along Red Canyon and Hebgen Faults are only the most recent of a lengthy history of similar movements.

For detailed and extensive description of the various amounts and types of movements involved with the 1959 Earthquake, the reader is referred to articles by Witkind et. al., and Myers and Hamilton in U.S. Geological Survey Professional Paper, page 435.

The offsets on tensional faults varied during the 1959 Earthquake from a maximum of over 20 feet at Cabin Creek, west of Red Canyon, to the barest minimal trace. Apparently maximum, movement coincides in some cases with dips in the bedrock which parallel and direction of shear stress, for when the faults begin to cut across the "grain" of the bedrock, minimal movements and eschelon patterns develop along the strike of the faults. Another complicating factor is the amount of and behavior of surficial rock materials approximately above the bedrock fault zone. Although there can be no doubt that the surface offset of these loosely consolidated materials is related in general to the subsurface position of the faults, the actual surface expression resembles a slump scarp in many cases. Actually, it is not unlikely that some of the multiple scarps with associated downhill (southward) movement of surface debris are truly slumps. It would take extensive excavating to reveal the true position of the faults under these circumstances, as fault planes are displayed in bedrock on the surface only in a very few places, notably along the north shore of the lake about four miles west of Red Canyon.

An interesting and important phenomenon in connection with tensional faulting is the tendency for those faults to exploit previous thrust faults as movement planes. It is obvious that the tensional faults closely parallel the regional patterns of the pre-existing thrusts along Hebgen Ridge and Kirkwood Ridge, but where the tensional faults actually coincide with the thrust planes, movement of reverse direction is superimposed on the thrusts. What was "up" on the thrusts is "down" on the tensional faults and vice versa. Considering that Laramide compressional structures at the mouth of Red Canyon tend to parallel Precambrian structures, and that late orogenic, including recent structures in turn parallel the Laramide, a principle is established which helps to predict the future behavior of faults in this area. Although we are dealing with conjectures which have no absolute basis in fact, it is nevertheless valid statistically to rely on the continuation of patterns established and continually renewed throughout the geologic past. Continually, renewed tensional offsetting has accentuated Kirkwood and Hebgen Ridges. Evidence of older recent but prehistoric fault scarps has been described by Witkind where the Red Canyon Fault encounters the Grayling Creek alluvial fan east of Red Canyon. In fact, every major structural valley in this region, the Gallatin, Madison, Yellowstone, and Helena Valley, to name a few, are bounded by similar range-front tensional faults, each displaying evidence of movement within the past few hundred thousand years at least, and most with scarps which could hardly be more than a few thousand years old. Thus, the Hebgen situation is unique only in that it involved the most recent expression of movement in the region. The broadcast of its earthquakes throughout this region can only serve to emphasize that seismic damage is not at all limited to the immediate area of faulting, as severe seismic shocks are encountered hundreds of miles from epicenters of quakes.

Myers and Hamilton (1964) suggest that faulting may not be the total cause of earthquakes, as the "kinetic energy of the subsiding masses about Hebgen Lake is adequate to explain the earthquake in other terms". This possibility further serves to emphasize the generalized nature of seismic danger throughout southwestern Montana and northwestern Wyoming and withdraws some of the stigma attached to the Red Canyon area as a focal point of seismic danger.

Offset by faulting is the dramatic surface effect of deeper movements which in total are perhaps more important than faulting. Precise leveling in a broad area encompassing the West Yellowstone and Madison Basins shows that the dominant effect in 1959 was downwarping of these basins. In fact, the intervening Madison Range, likewise, was involved with the downwarping. According to Myers and Hamilton, eastward trends of a structural system developed in the Centennial Valley area, southwest of Hebgen Lake, are being extended eastward across the West Yellowstone Basin to Yellowstone Park.

If the overall movement of 1959 was downward along broad warps, it is by no means certain that downward movement is the dominant trend in the long run. It is more logical to view the superior elevation of local ranges as the result of general upward movements and that extension of the Earth's crust, perhaps as a result of total uplift, is responsible periodically for relative subsidence of the many basins in this region.

It is even conjectured by Myers and Hamilton that the 1959 faults, spectacular as they appear, are only shallow slippage zones behaving like giant slump scarps at the north margins of basins whose axes of subsidence lie much to the south of the faulted margins. For instance, measurements indicate that the Hebgen Lake bottom subsided south of Corey Springs (just east of Red Canyon fan) for a total vertical distance greater than the offsetting on the Red Canyon Fault a few hundred yards north of the Springs. The fault is thus secondary to and the result of warping in the adjacent basin and not a fundamental deep seated feature in itself. If it were, perhaps volcanic sources would have been tapped, and perhaps the delicate exploitation of preexistent structures would not have been so precise. We view the faults near Red Canyon as coincident with the margin of a complex subsiding basin with axis of subsidence north of the geographic center of the basin. Thus, the south margin of the basin is but gently warped and slightly offset whereas the north is rather severely warped and offset.

Quite a different perspective is presented by Fraser, Witkind, and Nelson (1964) in which the Hebgen and Red Canyon Faults are viewed as old, deep-seated, fundamental tensional faults; the warping of the basin related to downward movement on the south side of the faults; and the extension of the eastward Centennial fault system across the Madison Range and into the West Yellowstone Basin as not valid. Whichever of the concepts is true, the surface map remains essentially the same and the general treatment of the fault system as a constraint in development likewise is the same.

GEOLOGIC HAZARDS AND LIMITATIONS

It is more practical to discuss the possible effects of the geologic environment on development in the zoning district than to approach the problem from the opposite standpoint. Most features of the geologic realm are simply not to be affected by man-induced activity. A possible exception is the whole aspect of mass wasting.

Six hazard types are proposed here: Mass Movement, Rock Fall, Snow Avalanche, Fault Offset, Seiche, and Limestone Solution Collapse. Each type has been further classified into zones which relate to the variance in severity of hazard which that particular type may have. For example, not all areas that have rock fall will have the same level of danger. The levels or degrees of hazard must then be categorized.

Mass Movement

Mass movement may be defined as the movement of earth materials downslope in the absence of direct fluvial processes. There are many types of mass movement, but basically they may be subdivided into two categories, flowage and slippage. The former includes such activity as solifluction, creep, and mudflow, while the latter involves brittle failure of the mass which behaves initially as an elastic body. Slumping and rockslide are typical examples of the latter type. Brittle failure causes rock fall, a separate category to be discussed in the next section. For convenience, the others will for be grouped together as mass movements and landslides. These mass movements take place at various rates which depend upon the amount of water available, slope angle, and types of constituent materials. The rates vary from imperceptible to very rapid. Clay-rich earth is particularly susceptible to mass movement in the Rocky Mountains, as it becomes easily mobilized when wet or highly disturbed. Shales and shaly marls are rock types with predominance of clay flakes in their makeup. They weather easily to incohesive masses of clay of unstable character. Mountain slopes underlain by these rock types will thus be most susceptible to mass movement.

Three mass movement hazard levels may be delineated:

1. Recently active mass movement with extreme limitation to construction: Even if inactive, these would be easily reactivated if undercut severely, if stress were applied in excess of their cohesive strength, or if the material in question is exposed to ingress of excessive water. The potential for movement here should be carefully weighed before any disturbance is made to the natural equilibrium. The best solution would be to avoid them altogether, but if building must take place on a landslide the construction should be done as far removed from the axis of the slide as feasible. Use of heavy equipment should be limited as much as possible, as this would apply a great stress to unstable material. The drainage of the landslide must be absolutely effective if the weight of the installation is to be supported correctly and not cause slow creep over the years. The hazard presented by these landslides to construction cannot be completely mitigated in most cases.

2. Rock units now stable but presenting serious hazard of mass movement if disturbed or wetted: This zone is congruent with the locations of the Park Shale and the Amsden Formation. The Amsden Formation crops out along the north-south ridge of Mount Hebgen, but its lithology consists of limestone and bedded chart, both stable. It does not outcrop in significance anywhere else on the mountain. But the Red Canyon fault exploits a weak shaly zone in the Amsden on Kirkwood Ridge and the east face of Red Canyon. Its presence should be noted but it poses no hazard to the development, because of its location. The Park Shale does outcrop along the east face of Mount Hebgen and deserves some attention. As noted above, it has already failed in several locations and may fail in others. Springs appear to have controlled the location of previous failure but conceivably the springs resulted after the slides. Thus special precautions must be taken where the Park is exposed to much water; the major springs that are found on the southeast face of the mountain, may make that particular area most hazardous to building. Mitigation of the hazards inherent to the Park is possible using the same guidelines as those for item 1 above. To reiterate, the Park Shale should be avoided for construction sites if possible.

3. Rock units not stable, but presenting moderate hazard of mass movement if disturbed or wetted: The Wolsey Shale and the Three Forks Shale comprise this zone. Both formations have been stable to date, and shall probably remain so in the future, but in the past they have not been subjected to the stresses of construction and heavy buildings.

Because of the very nature of the lithologies involved, these units should be treated with respect. If possible, they should be avoided, but if construction must proceed on them, the procedures outlined for construction mitigation should be followed.

Rock Fall

Rock fall results from brittle failure of rock along discrete weakness planes. Joints, bedding, shear zones and the like are typical of these planes and common in nearly every rock outcrop. The failure is caused by a change in the delicate balance between the force of gravity tending to pull the mass downward and the cohesive forces holding the mass on a steep slope. The force of freezing water or the shaking of an earthquake are two such outside forces that are effective, particularly if the rock bodies are already delicately held in position. A much larger total volume of rock is apt to fall during the short duration of an earthquake than during the relatively longer interval between major quakes. An obvious first requirement for any rock fall to occur is the exposure to slopes greater than the angle of repose of the materials involved. This varies depending upon the lithologies and climate of an area, but it is generally about 35 degrees. The greater the angle of slope in excess of that figure the greater the hazard from rock fall.

In the study area, rock fall may be considered as a serious hazard as many slopes are well over the angle of repose. The area also falls in a zone of high seismic activity. As the danger of rock fall increase with slope angle and also with the total number of vertical feet imposed by the slope, several levels of rock fall hazard must be delineated. For example, a vertical cliff 10 feet high is not as apt to produce rock falls as a vertical cliff 100 feet high. The run out zones beneath cliffs, likewise, may be relatively low in slope but may be targets for a rain of rock material from above where the kinetic energy is enough to cause rolling onto lower slopes. On Figure 2, three hazard levels are delineated only on the basis of probability.

In mitigating rock fall hazard, the most effective safeguard is to avoid the areas as building and activity zones. However, it may be statistically valid to allow activities involving infrequent passage particularly if judgment can be applied when planning such passage. To chance a building in such a situation would not be prudent in the long run, but to allow a cross country ski trail to pass beneath a cliff in mountainous terrain is a frequently tolerated situation. The skills of mountaineering and ski touring pit the climber or tourist against the hazards of nature to allow optimum possibility for negotiating the terrain in spite of the hazard involved. Common mountaineering knowledge would call for the leader to avoid exposure during rapid melt, during rapid freezing, heavy rain or snowfall, but the statistics of earthquake occurrence suggest that the chances of an earthquake catching a party beneath a cliff are of low probability. Nevertheless, warning signs and educational displays would be advisable if a public agency or corporation is to discharge their duties to the public properly.

Seiche

A seiche can be defined as the oscillation of water in a basin. Seiches generally result in a lake basin when a strong wind that has been blowing for several days finally subsides. The wind over a period gradually piles water up in the upwind portion of the basin. When the wind subsides, the oscillation of water in the lake begins. This is the sieche. The period of oscillation depends on the parameters of the lake and the strength and duration of the wind. This may vary from a period of a few minutes to one of several hours. While wind is the most common cause of seiches, other more catastrophic phenomena may cause them. An earthquake which either lifts or depresses all or part of a lake basin will cause a seiche. A seiche of this type is apt to be much greater than those brought about by wind. Flooding and even permanent submersion can result. In determining the area that might be affected by earthquake induced seiche, Witkind (1972) sets forth three assumptions that must be used: 1) A major local earthquake takes place, 2) the lake will be a high water mark at the time of the earthquake, 3) the early seiches produced will rise 30 feet higher than the water mark. Using these assumptions, which were in fact based on the seiches in Hebgen Lake produced by the 1959 earthquake, and date on permanent submersion around the north shore of Hebgen Lake, two zones of limitation may be drawn up:

1. Zone of possible permanent submersion. This zone is between the level of the reservoir and a contour 10 feet above the high water mark of the lake. This level is determined by data obtained from submersion in the 1959 earthquake. Should another earthquake occur, the submersion may be greater or less than this amount, but the 10 foot level is the best figure available. As with all seismic risks we are dealing with a probability and the safest way to mitigate against the hazard is to completely avoid it. Lakeshore development will surely take place, but should be limited to only those buildings necessary for lake use, such as marinas. The buildings should be built to sustain the full impact of a 30 foot seiche (not to be confused with a wall of water 10 feet high). It is important to remember in the mitigation of hazards that result from catastrophic events that the only sure alternative is total

avoidance of the hazard zone. As this is impossible less mitigating procedures have to be used, and there will always be some hazard.

2. Zone of greatest seiche flooding hazard. This zone extends from the shoreline of the lake to a contour 30 feet above the high water line of the lake. It would be best to limit construction in this zone, but what construction does take place should take into account the possibility of flooding.

Faulting and Warping

The limitations due to faulting and warping are founded on observations described in the Structural Geology section of this report. We view these limitations as among the most severe in the Hebgen region. Simply stated, development on or directly adjacent to faults of tensional origin showing movement during the 1959 earthquake, or in recent prehistoric time would be inadvisable, even though buildings offset by faulting of this type might not be completely demolished. It is within feasible risk to construct such projects as parking lots and roads in these zones, however, even though any movement would be expected to offset pavement, tilt or even tumble cars while parked, etc. We feel that rock fall in connection with faulting and involving sites beneath over towering cliffs is a greater danger than the threat by faulting offset alone. There have been no recently recorded fault offsets in North America with movement exceeding 20 feet, and in no case is the probability of cataclysmic opening of bottomless gashes in the Earth's crust a valid possibility, despite some popular and overblown rumors to that effect. The geology map on page 66 locates the fault planes as they are known.

Since there has been a tendency for offsetting (i.e. faulting) to be located along previously active but compressionally dormant fault lines, the exact location of former faults has become significant and important in a limitations sense. If these old fault lines have not been exploited by more recent movement, the rank of limitation is reduced to secondary importance. Compressional faults of the Laramide Orogeny will not today present danger from renewed compressional movement, as compression in the purest sense is not a characteristic of the phase of Post-Laramide mountain building in which the Northern Rockies are now involved.

The most difficult question regarding development and geologic hazards involves a zone across the Red Canyon fan which falls directly in line with the projection of the older Red Canyon tensional fault system. Witkind, et. al. (1964) show the mapped trace of the older Red Canyon fault projecting toward the fan, and abruptly terminated by alluvium of the fan east of the present creek channel. There is no direct and continuous linkup of the fault tract to the Hebgen Fault to the west. Presumably the Hebgen fault resumes the offset relationship several miles west of the fan, however, it is important to note that the westward sector of projection of the Red Canyon fault toward the fan is not based on strong field evidence, but two small scarplets produced by the 1959 event do extend westward toward the edge of the fan.

The most compelling evidence for modern trends of the Red Canyon Fault is the curved en eschelon swing of 1959 scarps and scarplets from an eastward to a northward strike around the east portal of Red Canyon. Thus, the Red Canyon Fault followed an old line of movement in 1959, eventually swinging around to coincide with the upright southwest limb of the Kirkwood Ridge Anticline. It seems valid to us to assume that where the Red Canyon Fault terminates along the west end of the Kirkwood Anticline, the basic tensional stress is transferred once again southward to the Hebgen Fault, which carries then for many miles further west. Since the stress patterns have been thus expressed in the past and present, it is realistic to say that this will be the trend of the future, and thus, the Red Canyon Fan will probably continue to be spared the fate of offset.

In spite of the statistical probabilities that the Red Canyon Fault will avoid the lower Red Canyon fan in the future as it has in the past, and that stresses in the area are already sufficiently relieved to preclude movement within the life of the Ski Yellowstone development, we have projected a low risk offset possibility zone across the Red Canyon Fan opposite the place of deviation of the fault. We believe it would be in the responsible interest of the corporation to err on the positive side of this difficult prediction and not take chances building where there is even a remote probability of offsetting along the fault system, even though the recent release of stresses makes this area possibly among the more stable at present in the entire region.

In addition to the actual fault offset hazard, a more widespread hazard related to shaking associated with earthquakes is to be expected in a seismic episode such as occurred in August, 1959. On a broad scale regional basis no single location in the study area is apt to be shaken harder than any other. For this reason, this hazard is not mapped. Relatively destructive shaking may be initiated not only by movement along the Red Canyon and Hebgen faults, however, but also from movements associated with any of the fault systems recently active in Southwest Montana, and the adjacent areas of Idaho and Wyoming. On the Modified Mercalli Scale, which rates the damage done by an earthquake on a scale of 1 to 12, the highest hazard rating in the Ski Yellowstone area would be related to movement on the Red Canyon or Hebgen

faults, or on newly initiated faults located with a few miles of Red Canyon. The damage rating could conceivably exceed the Modified Mercalli rating of 10 (some well-built structures destroyed; most masonry structures destroyed, rails bent, landslides considerable) recorded along part of the north shore of Hebgen Lake during the 1959 earthquake.
The damage done by the 1959 earthquake diminished rapidly away from the epicentral area, with West Yellowstone receiving a rating of 7 (little damage to well designed structures, serious damage to poorly designed structures). However, the sharp decrease leveled off at 7, areas as far away as Harrison, Montana also receiving a 7 rating, while ratings of 6 (felt by all, damage slight) continued into eastern Washington.

Two generalizations can be made from these observations: 1) for a structure to receive near total destruction it must be located near the epicenter of a severe earthquake; 2) minor damage to buildings, etc., can be sustained in areas over a hundred miles from a severe earthquake.

SUMMARY AND CONCLUSIONS

The geological information expressed in this report was written primarily for the Ski Yellowstone development, but is illustrative of development within the Hebgen Lake Zoning District and can be concluded that there are geological limitations within the area. However, as pointed out in this report, most geological limitations can be mitigated through special care in the development process. Some areas such as fault scarps, however, should be avoided.

Because of the limitations of the report, which is directed to the Red Canyon and Mount Hebgen areas, it can also be concluded that any major development should be required to furnish geological reports of the area to be developed.

Montagne in the Ski Yellowstone Environmental Study, concludes by saying, "We conclude that the geology imposes some constraints as to construction and use, but as long as the developers are respectful of these constraints and work around them or design for them, there appear to be no insurmountable difficulties. The principal areas of geologic sensitivities involve, in order of ranking from most threatening to least; 1) danger from fault offset, 2) danger from rock fall due to seismic shaking or human influence, 3) danger from landslides triggered by natural or human causes, 4) danger from snow avalanches on off-site areas, and on a limited few on-site areas, 5) danger from flooding caused by a seiche in Hebgen Lake, and 6) danger from solution collapse within a very limited zone on the east summit of Mount Hebgen."

Statistics indicate that frequency of faulting is of the order of 100,000 years and thus that faulting will predictably not seriously threaten Red Canyon within the expectable 200 year life of the project. This prediction does not invalidate the advisability to avoid construction in close proximity to recently active fault lines or rock fall areas, or the recommendation to limit construction to one story frame types in the "low risk fault projection zone". It is obvious that all buildings in the entire tri-state region should be built to conform with an engineering code allowing for Modified Mercalli scale earthquake shocks of magnitude 7. If the above conditions are met, and every indication appears that they will, disastrous effects will not occur even if faulting did reoccur within the life of the project."

TOPOGRAPHY - SLOPE AND VEGETATIVE COVER.

TOPOGRAPHY - SLOPE

The topography of the Hebgen Lake Zoning District varies from the highest point which is approximately 8,000 feet located east of Red Canyon Creek to the lowest point, which is Hebgen Lake at approximately 6,500 feet elevation. The steeper slopes are along the north edge of the zoning district with the exception of Horse Butte in the south part of the zoning district.

An important consideration of slope deals with the degree of possible degradation of hillsides in the form of erosion, soil, creep, and other movement as well as problems with human accessibility due to gradient and safety factors involved in building structures on steeper slopes. Also, in looking at a recreational area such as Hebgen Lake, it is important to consider the aesthetic qualities of the area and to prevent degradation of those qualities from scarring of visible hillsides.

The slope classification map, (Map 12) categorizes slope according to five classifications:

- 0 to 10 percent slope (for a 10 percent slope land rises 10 feet vertically for each 100 feet of horizontal measurement)
- 10 to 20 percent slope;
- 20 to 30 percent slope, (for a 20 percent slope land rises 20 feet vertically for each 100 feet of horizontal measurement),
- 30 to 40 percent slope;
- 40 percent or greater slope.

Preferably development should take place on slopes of less than 15 percent, however, it is possible to develop slopes between 15 and 30 percent. Greater hazards to the environment are present when slopes of that gradient are subject to man-made development. Any construction taking place in this category should proceed under strict environmental controls.

Man-made developments in almost all cases should not take place on slopes in excess of 30 percent. The greatest problems in developing slopes of this gradient include excessive scarring caused by earth construction work for foundation excavation and road excavation. Extreme erosion of exposed soils in deep cuts and fills, related drainage problems caused by high velocity runoff, and grade and access problems related to normal road systems are other problems encountered with development on these steeper slopes. Considering the geology of the area, any development on the steeper slopes would have to be questioned because of soil and rock stability.

VEGETATIVE COVER

The purpose of this section is not to give a detailed treatise of plant ecology in the Hebgen Lake Zoning District, but rather to relate major types of vegetative cover to the authentic values and possible degradation of those values through man-made developments.

In looking at information contained in the Ecological Land Unit section of this report, one may get a more comprehensive outlook on the vegetation of the Hebgen Lake Zoning District.

Basically, two areas of vegetation are of concern in this section:

1) Forested area or that area as outlined on USGS topographical maps as being woods and brush. Basically this would be those areas on the ecological land use map categorized as sub-alpine fir mountain slopes, sub-alpine forests, foothill aspen, and Douglas-fir lodge pole pine, bitterbrush flats, and Douglas-fir timber and white bark pine on high energy mountain slopes.

2) Marsh and swamps as designated on USGS topographical maps which would be those areas designated as wet lands according to the ecological unit map.

Primarily the forested areas of the zoning district correspond to the steeper slopes of the area and wet lands are basically areas along stream beds or near the shores of Hebgen Lake.

It is of concern in this study that those areas be protected from the scars of man-made development. Realistically, development can take place within the areas designated as woods and brush. However, great care should be exercised to assure that this vegetative cover is not destroyed to the point of losing its aesthetic value. As far as wetlands are concerned or areas on the vegetative map indicated as marsh and swamps, in most cases, development requiring individual septic disposal systems should be prohibited. Other types of development may be allowed but only under strict environmental control (See Map 13).

SUMMARY AND CONCLUSIONS

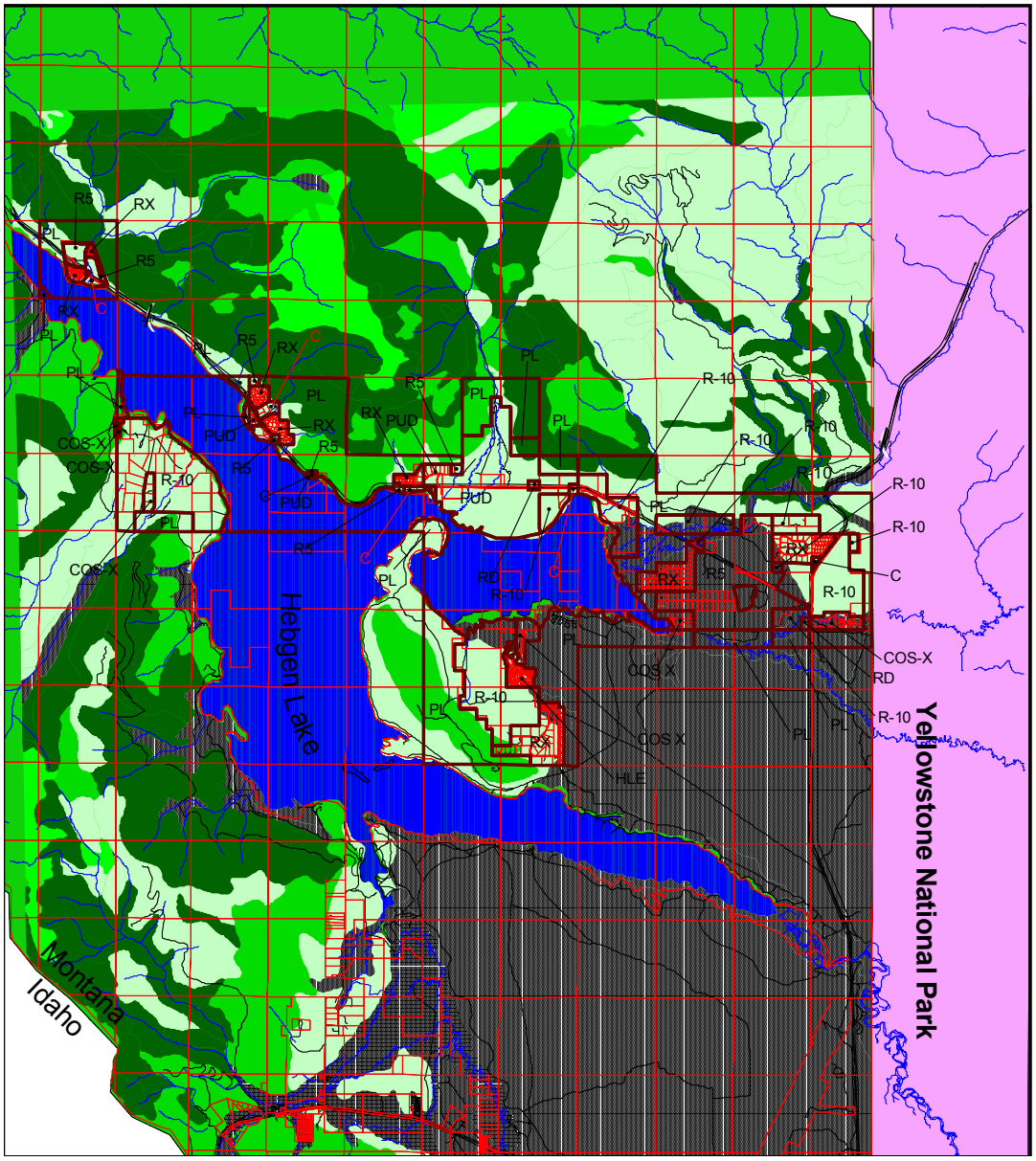
Slopes of 20 to 30 percent can be developed with proper environmental controls, however, to prevent degradation of the area, development on slopes of 30 percent or more should be prohibited.

Development can take place within some forested areas. However, regulations should be developed to prohibit clear cutting of forested areas for development purposes and the threat of wildfire should be seriously considered in the design and permit process for development in these areas.

Some development of wet lands may take place, but only under strict environmental controls. Development requiring individual septic disposal systems should be prohibited.

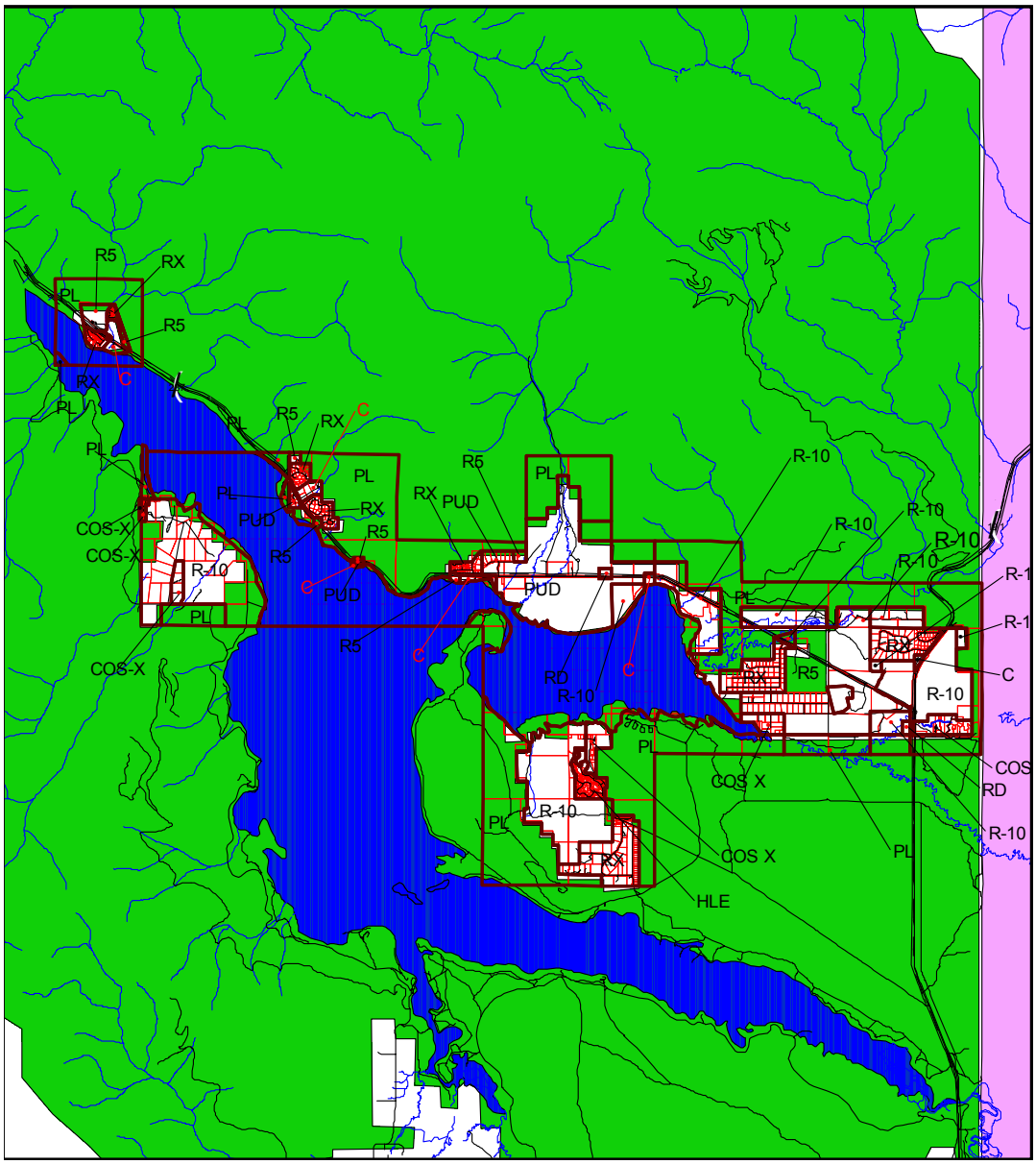
› 12

Hebgen Lake Zoning District and Surrounding Areas Slope Percentage



13

Hebgen Lake Zoning District and Surrounding Areas Land Cover



FISH AND WILDLIFE

Fish and wildlife, and their habitats, are an important part of the character of the Hebgen Lake Basin. Species and their habitat requirements are not based on land ownership, but rather, are intertwined with Yellowstone National Park (YNP), Gallatin National Forest (GNF) and private land found in the "Basin." The Hebgen Lake Zoning District encompasses important habitat and associated species important to maintaining the ecological, cultural and economic character of the Hebgen Lake Basin as a whole.

The purpose of this section is 1) To give an overview of fish and wildlife within the Hebgen Lake Planning and Zoning District, and 2) To describe concerns with, and general recommendations to mitigate, residential/commercial development in order to conserve the District's and the Basin's fish and wildlife resources.

Information for the 2002 revisions to this plan was gathered from Montana Fish, Wildlife and Parks; Montana Natural Resource Information System; the Gallatin County Fish and Wildlife Habitat Assessment (MSU); Interagency Grizzly Bear Study Team, Gallatin National Forest and Yellowstone National Park.

WILDLIFE

The Hebgen Lake Basin and for many species, the Hebgen Lake Zoning District, provides seasonal and year round habitat for a wide array of wildlife, some of which shift in and out of Yellowstone National Park. Species of mammals most notable include: elk, moose, mule and whitetailed deer, Rocky Mountain bighorn sheep, mountain goat, antelope, bison, black bear, grizzly bear, grey wolf, beaver, river otter, pine marten, and mink.

The Zoning District provides year round range for **elk and moose**. Because of the normally deep snow conditions found in the Basin, the tall willow communities along the Hebgen Lake tributaries (most notably: Duck Creek, Cougar Creek, Grayling Creek, and Red Canyon Creek) provide essential forage available to wintering elk and moose in this deep snow country. The south and west facing slopes along the north portion of the District and the Horse Butte area also provide pockets of important winter range for elk. The Englemann spruce and Douglas fir communities (on Horse Butte, along the Grayling and Madison Arms, and Kirkwood Ridge area) also provide important pockets of winter range for elk and moose.

Some of the elk that use the District are seasonal migrants from YNP, while others are, for lack of a better term, non-Park elk. Many of the non-Park elk leave the summer range provided in the basin to winter along the west face of the Madison Range (from Raynold's Pass to Indian Creek). Some of the elk that leave YNP in the winter also make the migration through the district to winter in the Madison Valley. Map 14 illustrates elk habitat within the zoning district and surrounding areas. Map 15 illustrates the extent of moose range in the Hebgen Lake Zoning District and surrounding areas.

Bison migrating out of YNP use portions of the Hebgen Lake Zoning District throughout the year. The majority of bison movement occurs during the winter months and is concentrated in the Horse Butte area, which provides important winter range. Bison also occasionally use the Duck/Cougar area. Map 16 shows the extent of bison winter range in the zoning district.

Because of the brucellosis disease transmission concerns surrounding this species, long-term management direction for its conservation is still unfolding under an adaptive management process. Under the Interagency Bison Management Plan, management strategies have been established. These strategies are designed to ensure the long-term conservation of free ranging bison in the Yellowstone System and to protect Montana's brucellosis-free status. The strategies also include numeric population goals and management actions that will be implemented to meet Montana's brucellosis concerns and stated population goals; which may be needed to protect the people and their property in the HLZD.

The Interagency Bison Management Plan has identified an area, Zone 2, where free-roaming bison will be tolerated. Part of this Zone 2 is private property. Safety concerns, growth patterns and the ability of the federal government to acquire large parcels will partially define what future management options exist for free ranging bison within the zoning district.

The entire district is within the recovery zone for **grizzly bears** in the Yellowstone system. When this species was placed on the Endangered Species List, the recovery zone was the defined area that was essential for the long-term persistence of grizzly bears in the Yellowstone Ecosystem.

In the 1960's, garbage dumps in the West Yellowstone area provided a substantial food source for grizzly bears. Many nights 10 to 15 bears could be observed feeding at these dumps. In 1970, open dumps were closed. Sanitary landfills

were “bear-proofed” and transfer stations installed at West Yellowstone and in Yellowstone National Park. Since that time grizzly bears have been relying on natural means of subsistence and habitat that furnishes them with food and cover.

Grizzly bear use is high throughout the district. However, the cooler, food rich riparian areas with tall willows are particularly important to bears in the summer. The winter range areas are important in the spring in providing available carrion from winter-killed ungulates.

Because grizzly bears are highly adaptable, the most important factor limiting grizzly bear populations is human tolerance. A key to increasing human tolerance is decreasing human/bear interactions. The level and intensity of human/bear interactions in the district will be determined by development patterns and food storage/human created attractants management. Because bears can be easily habituated to eating human food,garbage, bird feeders, horse cake, etc., the only recourse becomes the trapping and removal of the bear. This removal, in most cases, eventually ends in the death or permanent removal of the bear from the ecosystem. Map 17 illustrates locations within the Hebgen Zoning district where there have been conflicts between people and grizzly bears. Private land development in the zoning district may result in both the loss of grizzly bear habitat and a rise in conflicts with people because of an increase in attractants such as garbage, gardens, bird feeders, and ornamental trees and shrubs.

The Hebgen Lake Basin has a special **beaver/otter** management program, where beaver and otter are emphasized. Beaver are an important habitat manager in the basin because of the dams they build, the ponds they create, water storage they provide, and the willow communities they promote by making the area “wetter” creating healthy and expanded tall willow communities. The results of their activities provide: important habitat for waterfowl nesting and brood rearing; neotropical (song) bird breeding and nesting habitat; improved fish habitat (benefits to otter and mink) and of course tall willow providing forage for moose and wintering elk as well as secure cover for grizzly bears.

The Basin has been divided into seven distinct trapping units. During the last 12 years only one or two of those units are open to trapping annually, with very restrictive trapping regulations, i.e. one trapper with a quota of five to 10 beavers and one otter. The District encompasses three of the seven trapping units.

Wolf and wolf pack activity, resulting from the re-introduction of wolves into YNP, are now prevalent in the basin. Elk are their major prey, followed by, in no particular order of importance, moose, deer, bison, beaver and small mammals.

There are small populations of **mule deer** and **whitetailed deer** that winter in the basin due to a lack of available deer winter range. **Rocky Mountain bighorn sheep** and **mountain goats** occupy the mountains that ring the basin, most notably the Henry Lake Mountains, Taylor Hilgards and Monument Mountains/Kirkwood areas. A small herd of **antelope** that winter in the Madison Valley spends the summer in the basin, primarily in the sagebrush and grasslands west of the South Fork of the Madison.

Osprey and **bald eagles** nest in the basin and in the District. The area also provides limited wintering opportunities for bald eagles. Osprey are dependent on the high quality fisheries (trout and Utah chubs) of Hebgen Lake and its tributaries. Bald eagles rely on a multiple food source of trout, waterfowl, and carrion.

Hebgen Lake and its tributaries provide important spring and fall staging areas for migrating waterfowl (thousands of ducks and geese), as well as high quality breeding and brood rearing habitat. There are at least 12 pairs of **Canada geese** with nest in the area, producing about 50 goslings per year. **Trumpeter swans** also frequent the area.

Sandhill cranes are common in the basin and district; over 10 have been counted in the district. The combination of willow with adjacent grasslands is important to this species.

There are many other species of wildlife that are permanent or season residents of the District, i.e. wolverine, pine marten, other birds of prey including owls and other mammals, from northern pocket gophers to deer mice to coyotes. However due to limited space in this document, only those of particular note have been discussed.

FISH

The Hebgen Basin supports a variety of renowned coldwater fisheries and substantial aquatic habitat. Lakes, streams, and Hebgen Lake support mixed wild trout and native fish stocks providing a broad range of recreational fisheries and biological values. The Madison River, flowing from YNP, provides the preeminent recreational stream fishery above Hebgen Lake (a reservoir built on the Madison River). Smaller tributary streams of Hebgen Lake support resident introduced trout, native nongame species such as longnose dace and mottled sculpin, and vital spawning and rearing for

trout and mountain whitefish in Hebgen Reservoir. The fishery of Hebgen Reservoir is an important recreational resource in the area, ranking 20th in the amount of fishing pressure supported among waters statewide (Montana Fish Wildlife and Parks, 2000). Hebgen Reservoir supports wild populations of **brown trout**, **rainbow trout**, and **mountain whitefish**. Additional hatchery-reared rainbow trout are stocked annually (approximately 100,000) to enhance the fishery. Recent censuses indicate that stocked rainbow trout comprise less than 10 percent of the rainbow trout population. Introduced **brook trout** and **Yellowstone cutthroat trout** are present in low numbers. **Arctic grayling** and westslope cutthroat trout, once abundant native species in the area, are rare. **Utah chub**, introduced illegally in the 1930's, are abundant in Hebgen Reservoir. They are considered a nuisance species although they provide forage for aquatic and avian species.

All streams in the Hebgen Basin are managed as wild trout streams, each sustaining its native and non-native fish stocks through natural reproduction. The primary fisheries management goal of Montana Fish, Wildlife, and Parks for Hebgen Lake is to manage it as a wild, self-sustaining fishery. In order to maintain a self-sustaining fishery, tributary streams are critical for spawning and rearing of wild trout and mountain whitefish. Cool, clean water with healthy streamside riparian vegetation and clean gravels are critical to maintaining healthy reproduction. The Madison River, the South Fork Madison, Black Sands Spring Creek, Cougar Creek, Duck Creek, and Grayling Creek each provide critical spawning and rearing habitat for Hebgen Lake, as well as supporting resident fish populations and popular fisheries. In addition, Denny Creek, Watkins Creek and Trapper Creek each support some level of spawning for salmonids of Hebgen Lake. Preservation of these tributaries is critical to the long-term health of the fisheries. Research into the relative contribution of each stream and factors limiting reproduction in tributaries to Hebgen Lake is underway.

Waters of the Hebgen Basin and adjoining area also support native populations of westslope cutthroat trout, a species of special concern and candidate for listing under the Endangered Species Act. These populations are generally isolated in high elevation reaches of streams. High elevation lakes also provide substantial recreational fisheries in the area, for example Coffin Lake and Heart Lake.

SUMMARY AND CONCLUSIONS

Fish and wildlife are one of our most important assets. Protecting them while still allowing for homes, businesses, developments, highways, power lines and countless recreational opportunities is not easy. Fortunately, only 5,731 acres, or 36 percent, of the HLZD are not public lands. As a result, decisions made by the various government agencies will undoubtedly have a large impact on the fish and wildlife of the district. However, decisions of the HLZD guiding development could have permanent impacts on important habitat for fish and wildlife.

As stated in the 1977 Plan; it is hard to make specific regulations directed to protect wildlife. However, each individual proposed development would be required to look at affects on wildlife habitat.

There are some things that can be done to mitigate the impacts of development on wildlife and fish habitat within the HLZD that was established in 1977:

- Use incentives to conserve open space next to public land, riparian areas and other blocks of private land open space.

- Encouragement of conservation easements and federal government land purchases.

- Discouragement of development within the 100-year flood plain, which contains the wetland and riparian areas and will provide a buffer at the same time. Riparian vegetation stabilizes stream banks, filters fine sediments and pollutants, and provides cover and forage for fish and invertebrate life. Building homes and infrastructure within floodplains creates hazards to property and public safety, especially during spring runoff. To avoid impacts to streams and aquatic habitats, we can discourage construction of homes and infrastructure within the active floodway of perennial streams. For instance, most of the floodways of Duck and Grayling Creeks are approximated by the presence of large dense willow communities. The floodways of Red Canyon and Watkins Creeks are narrow and would be adequately protected by a narrow buffer.

- Education on food storage and bear conflicts. The large willow areas of the Grayling Creek Delta and Duck Creek can pose a human safety issue due to the high presence of grizzly bears using those areas during the spring and summer months. We can do our part to be educated on the food storage/human created attractants for grizzly bears in order to prevent conflicts. To minimize human/ bear conflicts and safety problems, any proposed development should be encouraged to provide a management plan that outlines how it will manage bear attractants.

- Enforcement of existing rules and laws is important. Examples include: weeds, dogs, feeding elk and bison, speed limits, fish and game laws, garbage, and illegal snowmobile or ATV use.

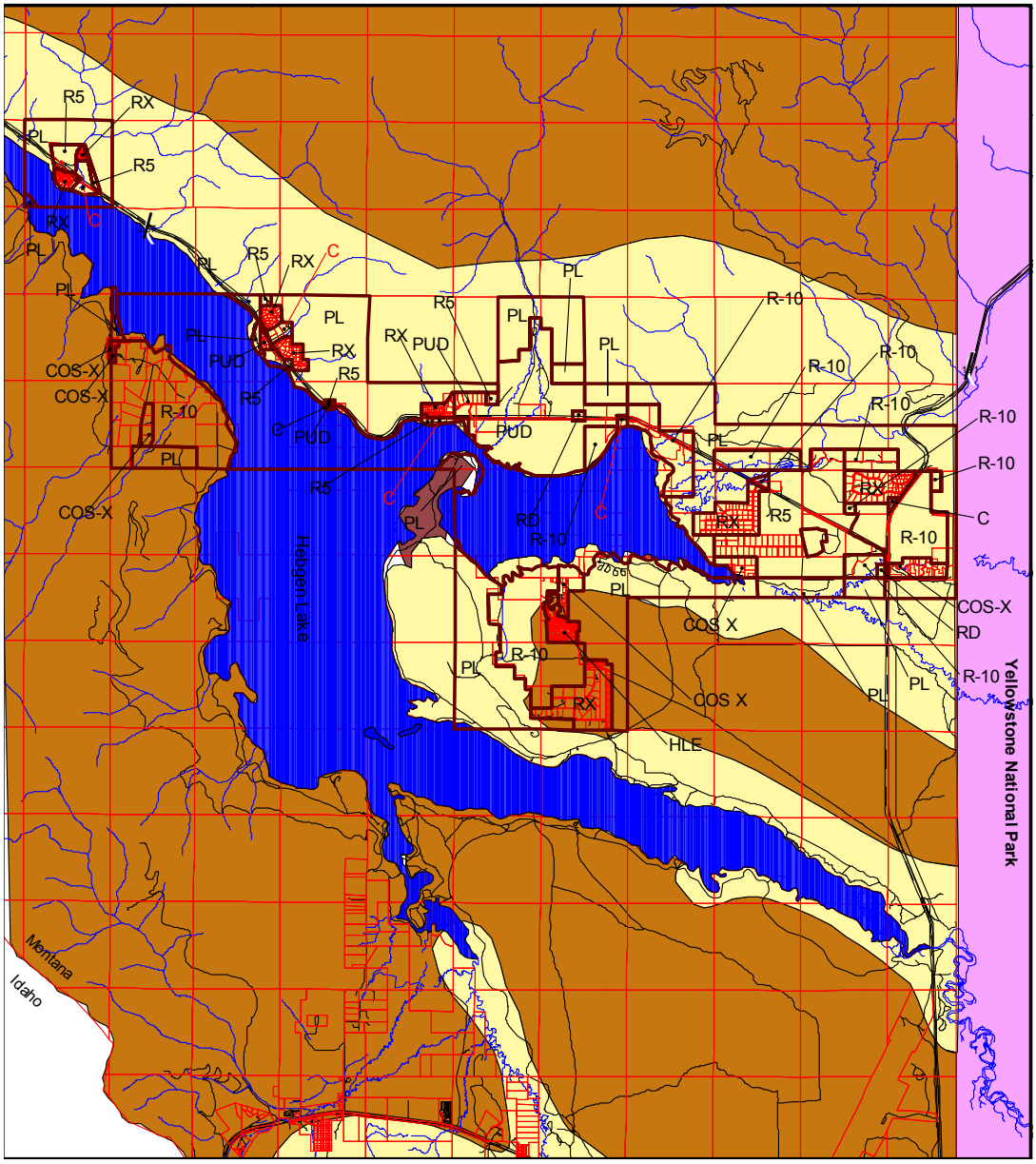
- Proper Waste Water Treatment. We can ensure Gallatin County makes its final inspection of new waste water treatment systems.

- Encourage the Forest Service to remove groomed snowmobile trails that go through winter range and bear habitat and put them near the highway right-of-way; such as in Grayling Creek.

- Barring new commercial areas and snowmobile, ATV, and personal watercraft rentals within the district. Such a prohibition will relieve pressures on wildlife.

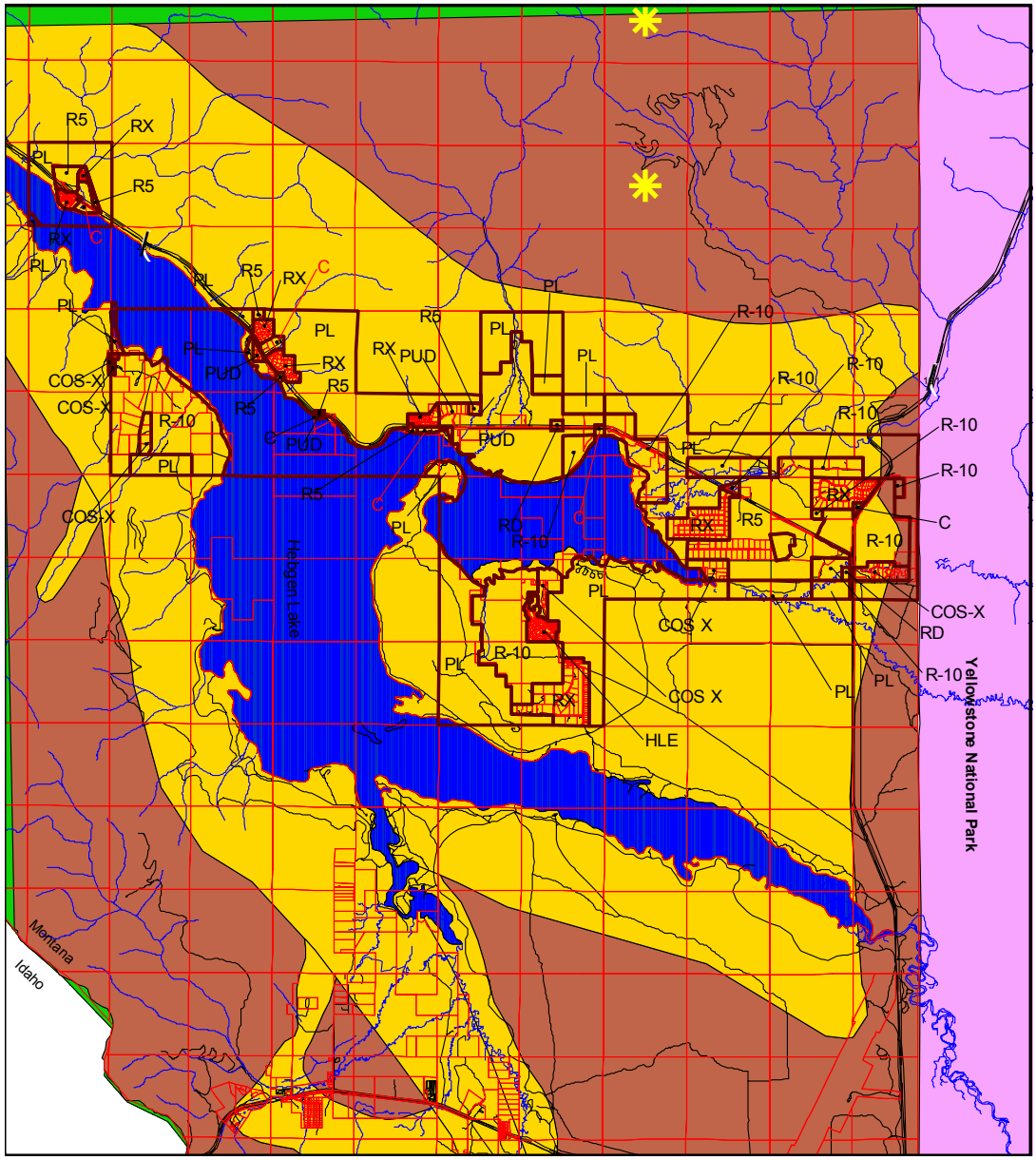
14

Hebgen Lake Zoning District and Surrounding Areas Elk Habitat



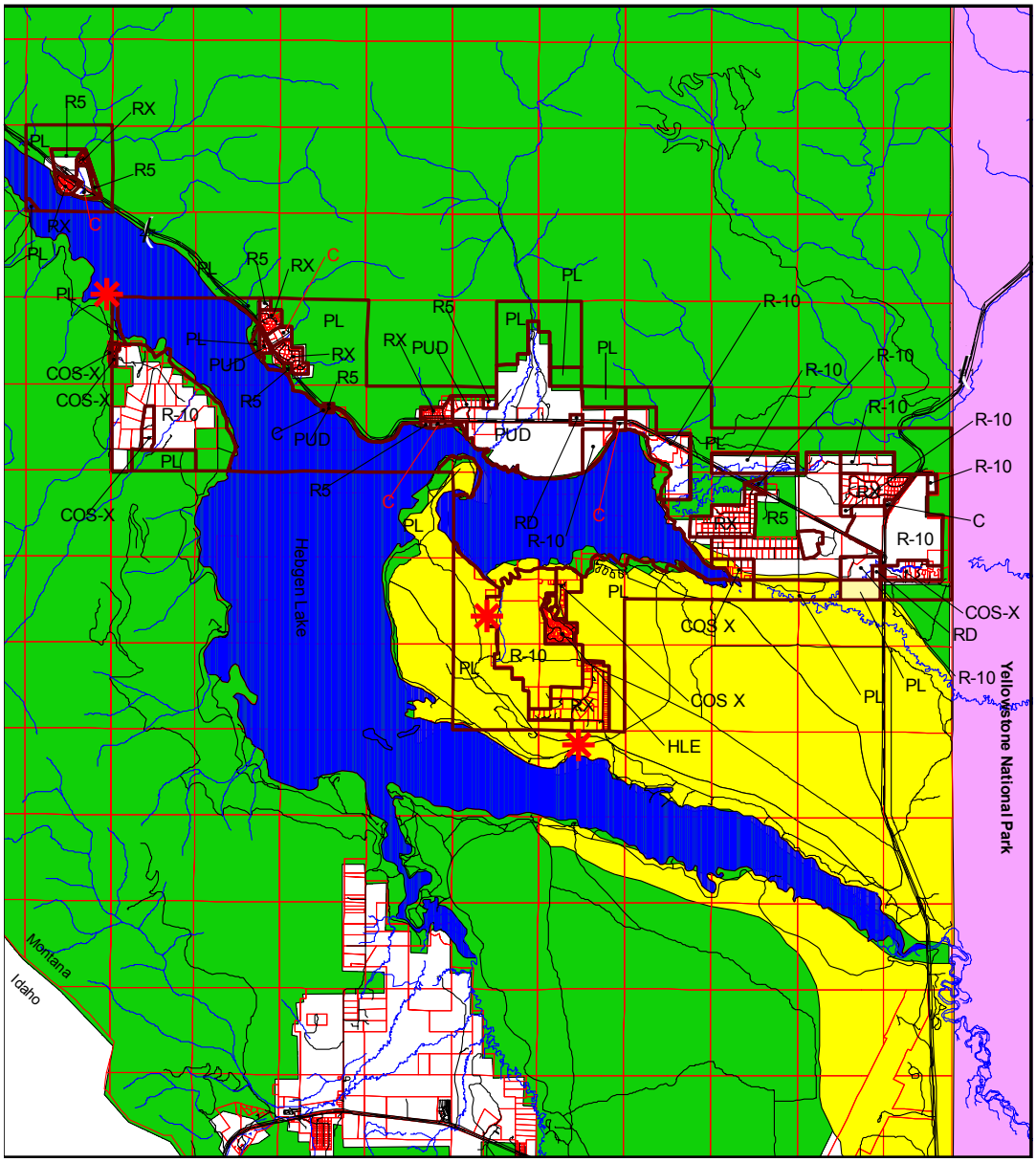
o 15

Hebgen Lake Zoning District
and Surrounding Areas
Moose Range and Lynx Occurances



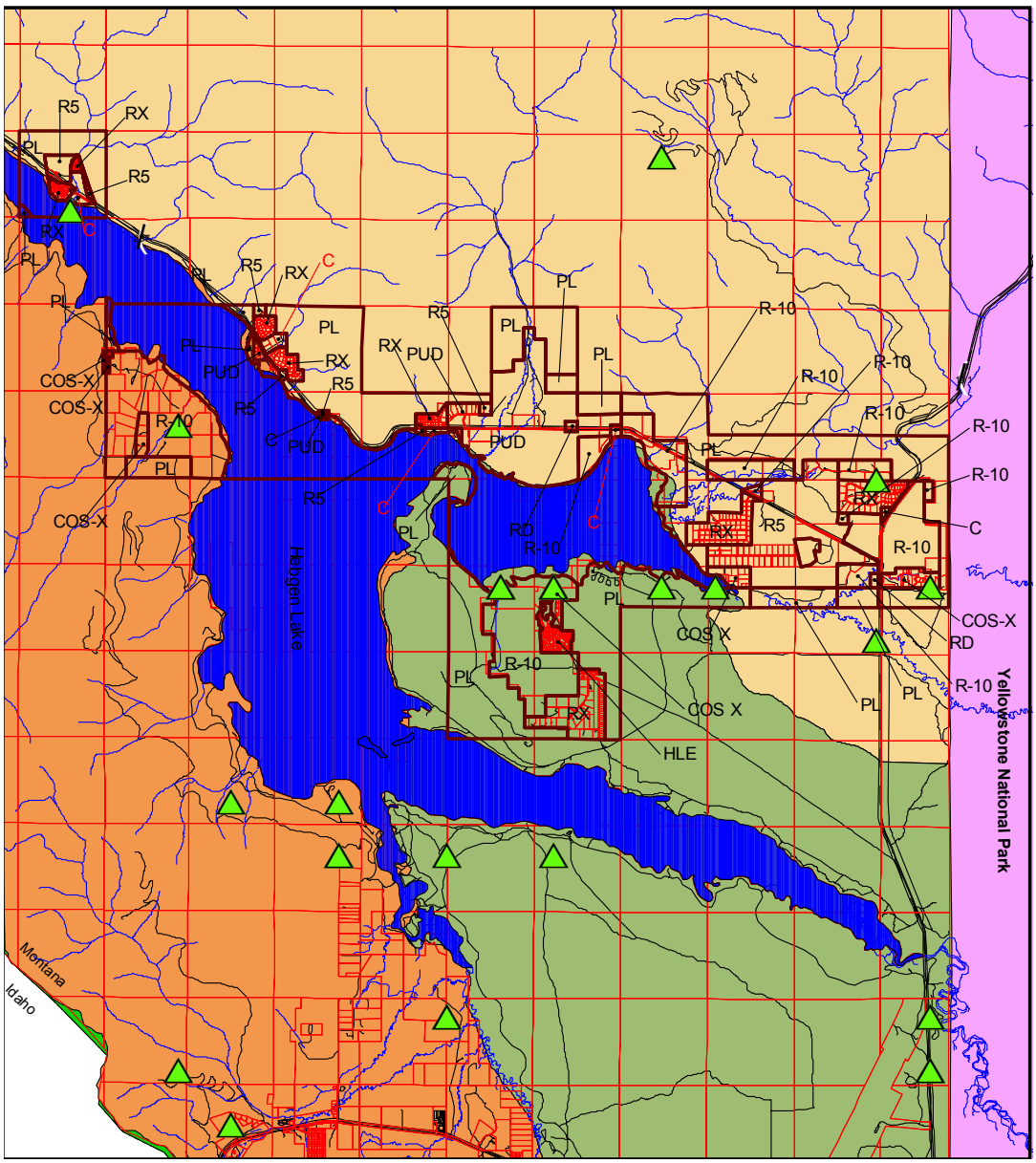
16

Hebgen Lake Zoning District and Surrounding Areas Bison Winter Range and Bald Eagle Nest Locales



17

Hebgen Lake Zoning District and Surrounding Areas Grizzly Bear Recovery Subunits and Conflict Locations



WATER RESOURCES

The purpose of this section is to give an overview of the water resources in the Hebgen Lake Zoning District and surrounding area. Information for the section, as it appeared in the 1977 plan, was quoted from the U.S. Forest Service's "Hebgen Lake Planning Unit Land Use Plan." That information is retained here, with minor editing and updating. Updated 2002 information on water quality, such that it exists, has been added to the conclusion of this chapter.

HEBGEN LAKE

This 12,500-acre impoundment on the Madison River was built in 1914 and is owned by Pennsylvania Power and Light, Montana. It is used as a regulating reservoir for the Madison River and downstream hydroelectric power plants. In January 2002, Falls River Rural Electric Cooperative, Inc. began the project licensing process for a hydroelectric project at Hebgen Dam with the Federal Energy Regulatory Commission. Any reader who wishes an overview of the resources of the Hebgen Basin should consult the January 2002, "Hebgen Dam FERC No. 11882 First Stage Consultation Document" prepared for Fall River Rural Electric by the Ecosystems Research Institute. While the title is not user friendly, this document provides an informative discussion of fisheries, water, and wildlife resources.

Hebgen Lake is an artificial impoundment of the Madison River. The full pool storage is 384,793 acre-feet of water. During the normal annual high water period (June-July) the lake is approximately 15 miles long, 3 miles wide at the widest point, and has a total surface area of about 20 square miles. During high water, the lake has a maximum depth of about 80 feet. Throughout an annual cycle, the water level in the reservoir undergoes an average vertical fluctuation of 20 feet.

From 1971 through 1974, the Forest Service, the U.S. Department of Agriculture's Soil Conservation Service, Fish and Game Commission, and Montana Power Company, the predecessor to PPL, worked cooperatively to put in place a reliable snow forecast system to use Hebgen Dam as a leveling device during the spring snowmelt period. What triggered this action was the Earthquake Dam. The spillway cut through the slide will carry only 3,500 cubic feet per second without eroding the spillway and causing degradation, both physical on-site and downstream fishing quality. By coordinating the outflow from Hebgen with the inflow of Cabin Creek, Beaver Creek, and inflow into the reservoir; and considering the reservoir capacity and snow yet to melt and run off, a rate of discharge from Hebgen Dam is computed. The end result is a more constant stream in the Madison River and a lowered potential for further degradation of Earthquake Dam. This venture has caused Hebgen Reservoir to be at a lower pool level at the start of fishing season, and several boat ramps are not usable until into June. The reservoir is not filled to full pool until after the peak runoff has occurred.

It is planned to incorporate this reservoir management plan into the Federal Power Commission license when it comes up for review.

Hebgen Lake is used for fishing, swimming, sailing, boating, water skiing, and waterfowl hunting, and is the general focal point of this district. There are campgrounds, boat ramps, resorts, and marinas located on public and private lands around the lake.

There are 57 miles of shoreline with 9.2 miles in private ownership and the remainder National Forest. On the National Forest segment, 10.9 miles are largely inaccessible because of swamps or cliffs.

Another 24.4 miles would require varying degrees of alteration, consisting of log and debris removal, to make them suitable for recreational use. Of the remaining 12.5 miles of usable public land frontage, 3.1 miles are in front of summer homes, 0.5 miles at marinas or resorts, 0.7 miles at a campground, and 8.2 miles are undeveloped.

Aquatic vegetation, mainly pondweed, flourishes in the lake during the warm period of July and August and impairs boating and fishing in the more shallow portions of the lake.

After the 1959 earthquake, district personnel observed a four-foot layer of organic debris (peat) exposed from the bottom of the lake. This is significant considering that the lake is only 60 years old.

Lake Use

Recreational use of Hebgen Lake occurs mainly in June, July, and August. The season is short due to the short summer at this high elevation. The most popular recreational uses on the lake are motor boating, water skiing, fishing and swimming.

At the present time Hebgen Lake has seven marinas/resorts/campgrounds, about 149 summer homes, and four campgrounds with two Forest Service boat ramps, for a combined total capacity of about 2,530 persons at one time as indicated in Table 11.

Table 11:

RECREATION DEVELOPMENTS ON HEBGEN LAKE

Development	Approximate Capacity	Boat Ramps
Kirkwood Resort	150	1 private
Yellowstone Holiday	250	1 private
Great Springs	150	1 private
Cory Springs	50	1 private
Lakeview	50	1 private
Madison Arm Resort	400	1 private (FS permit)
Firehole Ranch	50	
Summer Homes, private lands (75)	375	
Summer Homes, National Forest (74)	365	1 private (FS permit)
Rainbow Point Campground	430	1 Forest Service
Lonesomehurst	100	1 Forest Service
Hebgen Mountain Inn	50	1 private
Cherry Creek Campground	100	
Spring Creek Campground	60	
TOTAL	2,580 persons	10 boat ramps

Water Quality

"Madison River water is a sodium-bicarbonate-chloride type with high concentrations of silica and higher than normal concentrations of potassium and fluoride.

"Duck and Grayling Creeks are calcium bicarbonate water, whereas Red Canyon Creek is a calcium-sulphate-bicarbonate type. Red Canyon Creek has the highest content of total dissolved solids followed in order by Madison, Grayling, and Duck waters.

"Because of these chemical differences, water masses in Hebgen Lake can be identified as to origin. High sodium, chloride, silica, and fluoride content indicates Madison River water whereas high calcium water indicates Duck, Grayling, and Red Canyon water. Red Canyon water can be differentiated from Duck and Grayling Creek waters.

“Hebgen Lake is a predominately sodium bicarbonate lake with relatively low concentrations of potassium, calcium, magnesium, chloride, and sulfate. Phosphate was unusually high and it appeared that nitrate might be the most important limiting factor to primary production...

"Shortly after the disappearances of ice cover in early May and with the beginning of spring runoff, the upper five feet of Grayling Arm water...originated from Grayling Arm tributaries and overlaid water of Madison River origin. Phosphate-phosphorus concentrations were less than 0.01 mg per liter in surface water and greater than 0.22 mg per liter in the

underlying water. Ammonia nitrogen was undetectable at all depths, and nitrate nitrogen concentrations were 0.01 mg per liter from surface to bottom.

"By the first week in June as a result of high discharge from snow pack melt the upper 15 feet of water in Grayling...originated from Duck, Grayling and Red Canyon Creek runoff. Madison River water was found only near the bottom where 0.02 mg per liter was present. In contrast to the behavior of phosphate ammonia-nitrogen levels had risen to 0.15 to 0.30 mg per liter and nitrate-nitrogen levels to 0.010 to 0.066 mg per liter.

"With decreasing discharge in late June water quality became more dependent upon the effect of wind-driven currents. With westerly winds water more characteristic of Madison River water was forced into the Grayling Arm as was the case for June 15 and July 25. As a result of west winds piling up water in the Grayling Arm a counter-current was set up that flows westerly below the surface. This situation is clearly evident from examination of the chloride data on July 25 where high chloride water is present in the upper five feet and lower chloride water is present below 15 feet.

"Chloride data on June 15 and July 6 showed the effects of easterly wind flow. Low chloride water characteristics of the Grayling Arm tributaries, overlies high chloride water brought into the Arm by a counter-current flowing from the west.

“Ammonia-nitrogen concentrations ranged from 0.36 to 0.93 mg per liter on June 15 to 0.20 to 1.06 mg per liter on June 26. Nitrate-nitrogen concentrations ranged from 0.010 to 0.032 mg per liter on June 15 to 0.020 to 0.024 mg per liter on June 26. Subsequently, ammonia-nitrogen levels dropped to 0.06 mg or less on July 25 and nitrate-nitrogen levels to 0.010 or less.

"The nitrogen levels observed in June were well above concentrations observed in the tributary streams. Since they were present when lake level was rising from its seasonal low to the high water stage, the increase in nitrogen was almost certainly due to ammonification and nitrification of flooded organic matter.

“Phosphate-phosphorus during the last half of June and July were higher than the phosphorus concentrations observed in the Grayling Arm tributaries. These higher levels were most certainly due to mixing of high phosphate Madison River water with Grayling Arm water.

"Since Grayling Arm has a fluoride content greater than 1.5 mg/l most of the time and Red Canyon Creek has a sulfate content greater than 250 mg/l during low flow, neither can be considered as a source for potable water.

Phytoplankton

"Maximum chlorophyll concentration of 42.59 micrograms per liter was seven times as great as those measured by Martin in the main body of Hebgen Lake. Maximum cell volume of 14.75 cubic millimeters per liter was more then two times as great as the maximum observed by Martin. The peak phytoplankton density was associated with the highest observed phosphorus concentrations and the lowest observed nitrogen levels.

"The dominate species including three blue-greens (Lyngbya bingei, Anabeana spiroides, Aphanizomona flos-aqua) and two diatoms (Asteri onella formosa and Fragilaria crotensis) were also found to be dominant by Martin. Lyngbya and Anabenna were by far the most important.

"Although the inorganic nitrogen compounds present in June were almost completely taken up by the plankton in July the nitrogen-fixing proclivity of blue-green algae makes them independent of inorganic nitrogen compounds as long as adequate phosphorus is present. Because of its shallowness and higher ratio of bottom area to water volume, Grayling Arm appears to be more productive of phytoplankton than deeper portions of Hebgen Lake. The shallowness allows wind to mix water throughout the water column and promotes exchange of substances between the sediment and the overlying water.

Stream Flora

"Duck Creek had the most diversified flora of all streams. Rooted aquatics particularly water-buttercups were abundant as well as a diatom coating on the substrate. Grayling Creek was characterized by a diatom flora and had no conspicuous rooted aquatics. During high water, plant growth in Red Canyon Creek was severely limited by the heavy silt load. After cessation of high flow the upper reach of the stream was characterized by diatom growth. The lower reach had a very unaesthetic growth of a filamentous algae (Vaucheria). Weed beds were present at the mouth. Based on chlorophyll concentrations that accrued on plexiglass slides, the ability of lower Red Canyon Creek to support algal growth was far

greater than upper Red Canyon Creek, Grayling Creek and Duck. Duck Creek was slightly more productive than upper Red Canyon Creek and Grayling Creek.

Table 12

CHEMICAL ANALYSIS OF HEBGEN LAKE TRIBUTARIES

mg/l

	Ca	Mg	Na	K	HCO_3	Cl	SO_4	F	SiO4	PO_4-P	NH_3-N	NO_3-N
Madison River	5.75	0.34	69.92	7.82	116.51	47.60	10.2	6.35	92.0	0.082	0.012	0.000
Duck Creek	12.20	1.80	5.98	1.33	56.10	1.25	7.5	1.01	27.5	0.030	0.03	0.042
Grayling Arm	18.20	2.50	1.84	0.78	68.90	1.00	3.0	0.48	15.0	0.005	0.06	0.014
Red Canyon River	140.80	21.40	10.58	2.19	146.40	2.00	248.0	0.90	8.0	0.005	0.02	0.014

Wright, July 6, 1973

Stream Insects

"Duck Creek, Grayling Creek and upper Red Canyon Creek supported the normal may fly, nymphal, and midge fly larvae populations that may be expected in swift, clean, cold mountain streams. The insect fauna of lower Red Canyon Creek was very depauperate and restricted to midge fly larva that are tolerant of silt.

SUMMARY AND CONCLUSIONS

"Federal Environmental Protection Agency water quality standards recommend that total phosphorus levels should not exceed 0.01 mg per liter in lakes and 0.10 mg per liter in rivers and that nitrogen levels should not be excess of 10 times the phosphorus levels. In the late 70s, all streams flowing into Hebgen Lake met these criteria. However, levels of ortho-phosphorus are usually in excess of 0.01 mg per liter in the lake. Highest nitrate and ammonia levels were associated with the flooding of lake bottom exposed during drawdown. This was followed in July (1973) by an explosive growth of blue-green algae in the Grayling Arm. By the end of July practically all of the inorganic nitrogen supplies were used up while ample phosphate for phytoplankton growth still remained.

“... the relatively low levels of inorganic nitrogen compounds...[may be] the chief limiting factor for algal production in Hebgen Lake. Hebgen Lake, because of warm summer temperatures, high chloride content and relatively high phosphate content, is a suitable environment for blue-green algal growth. Two of the dominant species of blue-green algae are known to fix elemental nitrogen ammonia. It has been shown, however, that nitrogen-fixing blue-green algae will use nitrogen compounds preferentially before fixing elemental nitrogen. Thus, any increase in the levels of ammonia and nitrate in the lake would tend to cause an increase in blue-green algae as well as other non-nitrogen-fixing species.

"Of the three major tributaries draining into [Hebgen Lake], Grayling Arm and Red Canyon Creek have the lowest recreation potential. The stream is extremely turbid during high runoff. At base flow levels the lower reaches below the highway bridge possess a dense growth of filamentous algae. It also presents the greatest hazard for development because of the erodability of its water shed and the alluvial deposits at its lower reaches. While there is not much to be

lost by increasing the silt load in the stream itself the important fact is that this stream is the greatest contributor to siltation of the lake...

"Both Grayling and Duck Creek are clear running streams. Below the highways fishing access is difficult because of the dense growth of willows. However, because of the importance of the willow growth and swamps to wildlife and waterfowl nothing should be done to improve fishing access to this habitat. Probably the largest single potential for damage to the water quality in the district is the eminent danger of a hazardous spill caused by a truck accident on the Grayling Creek corner which is on Highway 191 near the NE corner of the district. Efforts should be made to straighten this bad section of highway.

"Of the two streams, Duck Creek is the most productive having both weed beds and good benthic growth. Brook trout in the stream itself and Brown and Rainbow at the mouth are the most important species. Although Grayling was once an important species in the stream, this is no longer true since Grayling is an unsuccessful competitor with Rainbow Trout which was introduced into the stream."

Water Quality Update:

The *Consultation Document* offers the most recent compilation of water quality data for Hebgen Lake and the river below. There is not recent compilation of water quality data for the tributaries that flow through the Hebgen Lake Zoning District into Hebgen Lake (and which could be affected by development activity), but it should be noted that Red Canyon and Watkins Creeks appear on Montana's 303(d) list as moderate priority streams. This list, which all states compile to comply with the federal Clean Water Act, is a roster of streams that do not fully support the expected beneficial uses, including fisheries.

Red Canyon and Watkins Creek appear on the 303(d) list because the riparian corridors along these streams show signs of degradation, including the loss of vegetative cover, bank erosion, and siltation. The status of these streams will be re-assessed in 2003, during the development of a TMDL – total maximum daily load – study of the Upper Madison River Watershed.

While Red Canyon Creek and Watkins Creek watersheds are most vulnerable, clearing of vegetation (especially riparian or wetlands vegetation), road construction, and other development activity could also adversely affect water quality in other tributaries and, ultimately, Hebgen Lake.

ECOLOGICAL EVALUATION

The objective of this ecological section is to present basic information used to determine land suitabilities, capabilities, limitations, and natural resource values are determined. These determinations, based on ecological principles, form the basis for making management decisions and predicting future problems. Information for this section is taken directly from the Hebgen Lake Planning Unit, Land Use Plan by the Forest Service. However, only those ecological land units that are within the Hebgen Lake Zoning District are included in this section. Maps illustrating the suitability of ecological land units for road construction and resorts are mapped according to limitations and included at the end of this section.

An ecological land unit (ELU) as used in this report is defined as a complex of living and non-living components, each interacting with the other to function as an integrated system or unit. The area within a given ELU could be expected to respond in a unique and predictable manner to a land management activity. While each of the individual components has its own significance, it is the combined effect of all and the interactions among them that are important. It is this total complex, rather than the individual components, that governs production possibilities and limitations, defines technical problems, and determines the type and intensity of use.

The environment in the Hebgen Lake Planning Unit has been evaluated for decision-making mainly on the basis of the ecological land unit (ELU) descriptions. The ELU's are described and delineated considering climax plant communities, soils, geology and land form.

The ELU's have been identified on color aerial photographs of 1971 vintage and were field checked for reliability. An important limitation is that these ELU's often consist of large areas actually containing a number of closely associated “sub-ecosystems." Interpretations must be made for the dominant characteristics of these ELU's. The boundaries of these ELU's are not absolute. They represent ecotones, or tension zones, where one ecosystem grades into another. In some cases this natural boundary is abrupt; in other cases it represents a gradation for which no definite boundaries can be readily identified.

Considering those limitations, the descriptions of the various characteristics of the ELU's, their interrelationships, and the activity suitability provide the basic information from which land uses are determined and management decisions are made. Interpretations from this information are used to indicate general consequences of management decisions, to anticipate future problems, and to design alternative solutions to management. The defined ELU's also serve as distinct units for more detailed sampling and inventory of data and results in the future.

Following a brief description of each of the ELU's as classified in the Hebgen Lake Zoning District. Table 13 summarizes the important characteristics of each ELU. The ELU numbers do not necessarily represent any topographic position. ELU numbers 4, 9, 10, 12, 15, 16, 17, 18, 19, 21, 26, 27, 28, 29, 30, 33, and 34 are not found in the Hebgen Lake Zoning District and are not included in this report. (For full treatment of the ELU's in the Hebgen Lake Planning Unit, see U.S. Department of Agriculture, Forest Service, Environmental Statement - Final, November 1975)

ECOLOGICAL LAND UNIT DESCRIPTIONS

1. STREAM BOTTOM

Characterized by stream terraces, fans, and some colluvial material. It is located adjacent to streams or intermittent drainage ways. Soils vary from fine to medium coarse, are moderately deep to deep, vary in drainage, and are usually rich in organic matter and mineral colloids. A rich variety of vegetation occurs because of the permanent water supply. Dominant species are cottonwood, aspen, willow, and alder.

Table 13:

ECOSYSTEM CHARACTERISTICS

ELU	Physical and Vegetative Interpretations				Wildlife Biotic Interpretations					
	Surface Erosion Hazard	Slump Erosion Hazard	Production of Cellulose		Winter Range Moose and/or Elk and/or Deer	Sheep and/or Goat	Grizzly Bear	Waterfowl	Sandhill Crane	Fisheries
1.	L	O	O		X		X*		X	
2.	M	L	LM							
3.	L	O	O		X		X*	X	X	
5.	H	L	O		X					
6.	H	O	O		X	X			X	
7.	M	O	O		X			X		
8.	H	O	O							
11.	L	O	H		X	X				
13.	M	O	L		X	X	X*			
14.	MH	O	O		X	X				
20.	L	O	O		X		X*	X	X	
22.	L	M	MH		X				X	
23.	L	-	L		X			X		
24.	L	-	O		X				X	
25.	M	L	L				X*			
27.	-	-	-					X		X
31.	L	-	L		X					
32.	L	-	O		X					

Legend

H – High
M – Medium
L – Low
O – Less than low
- Not applicable

Legend

X – Occurrence

X* – Potential Grizzly Habitat

2. LAND FLOWS

Undulating broken land surface with numerous potholes and undrained areas characterize this unit. Slopes vary from 5 percent to 50 percent. Soils are dominantly clayey in texture and vary in drainage. Vegetation varies depending on the water supply but includes a broad spectrum ranging from cattails to lodge pole pine.

3. MOUNTAIN MEADOW

Located on ridges, benches, basins, and fans usually within Douglas-fir and alpine fir habitat types on flats and slopes up to 40 percent. Soils are dominantly finely textured with accumulations of organic matter. These are fertile soils with grass vegetation predominating.

5. XERIC LANDFLOWS

The land surface is uneven with landslide surface undulations, slide paths, and fracture plains on slopes of 20 percent to 80 percent. Predominantly well-drained, finely-textured soils prevail. Vegetation is predominantly grass with scattered Douglas fir and limber pine trees.

6. STEEP ERODED SCARPS

Consists of 40 percent to 100 percent slopes on high-energy slopes between 5,000 and 8,000 feet elevation. Found on sedimentary and volcanic formations with predominantly shallow, finely-textured soils. Erosion is evident. Grasses and forbs are the dominant vegetation.

7. GRASSLANDS

These units are on gently sloping and rolling foothills where moisture is insufficient to support tree cover. Soils are of medium depth, medium-fine texture, with a darker humus cover. Grasses are the dominant vegetation; but scattered Douglas fir, limber pine, and white bark pine are found.

8. BREAKS

Consists of river faces, cliffs, and steep mountain slopes from 50 percent to over 100 percent. Includes scattered patches of Douglas fir, white bark pine, and limber pine trees among bare rock outcrops, talus slopes, and boulder fields. Soils, where they occur, are skeletal, fine-textured, and shallow. This area is hot and dry in summer months.

11. SUB-ALPINE FIR MOUNTAIN SLOPES

Generally occurs on uniformly steep slopes between 30 percent and 100 percent at the 7,000 to 8,000 foot elevation range. Soils developed from sedimentary and volcanic formation have thin organic surface mat, may be skeletal, and are shallow to moderately dry. The climax vegetation type is sub-alpine fir, whortleberry, but most of the vegetation is sub-climax lodge pole pine.

13. SUB-ALPINE FOREST

Forested cover on steep slopes between the 8,200 and 9,500 elevation range characterize this unit. Soils are of sedimentary and volcanic origin, have a thin organic mat, may be skeletal, are finely textured, and may be shallow to moderately deep. The over-story is sub-alpine fir, white bark pine, and lodge pole pine; the understory is generally low-growing plants such as Indian paintbrush, geranium, and lupine.

14. ROCK OUTCROP FOREST

This unit has trees scattered among bare rock outcrops and talus slopes on 40 percent to 100 percent slopes, breaks, and cliffs. Soils are generally skeletal, shallow and fine-textured.

20. WET MEADOWS

This type occurs on flat lands along stream bottoms, lakes, and potholes. The water table is close to the surface all seasons of the year. Soils are deep to moderately deep, poorly drained, non-skeletal, with organic surface horizons. Sedges, rushes, and willows dominate the unit.

22. FOOTHILLS ASPEN AND DOUGLAS-FIR

This unit spans the zone between the lower grasslands and the forested mountain slopes and occasionally occurs higher on the mountains. Aspen occupy the more moist sites and Douglas fir, the xeric sites. Soils are brown, moderate to deep, with some coarse fragments, mixed drainage features, moderately deep to deep, and high in organic matter and mineral colloids. They are highly productive. The mosaic of deciduous and evergreen vegetation gives this ELU its distinctive color pattern on the landscape.

23. LODGEPOLE PINE - BITTERBRUSH FLATS

This ELU is located on flat terrain mostly on the old lake bed surrounding West Yellowstone. The soils, derived from obsidian sands, are very shallow, drouthy, and well drained. The substratum is six to 10 inches below the surface. The overstory is lodge pole pine which occurs in a mosaic of ages and patterns over the flats with a bitterbrush understory and associated vegetation. Some of the denser stands have no understory.

24. XERIC MEADOW

This is a flat meadow lying on the former lake bed surrounding West Yellowstone. The meadow has the appearance of a sagebrush and grass flat with a few scattered trees. The soils are shallow, well drained, and of sandy loam texture.

25. DOUGLAS FIR, WHITEBARK PINE, AND LIMBER PINE ON HIGH MOUNTAIN SLOPES

This ELU is on steep slopes sometimes exceeding 80 percent and containing rock outcrops at elevations up to 8,500 feet. The soils are of variable depth, skeletal, and fine-textured. Usually the overstory is Douglas Fir at lower elevations and white bark pine at higher elevations with limber pine throughout.

27. AQUATIC SYSTEMS

This ELU contains all the lakes, reservoirs, and streams of the unit. Most of the lakes are in the high, recently glaciated cirques. The streams are generally swift with a gradient of over 5 percent, although they often contain stretches of slow water. Most of the waters contain fish with these species being most common: Yellowstone cutthroat trout, brook trout, rainbow trout, brown trout, and mountain whitefish. The most abundant bottom fauna includes stoneflies, caddis flies, may flies, plankton, and freshwater shrimp.

31. LODGEPOLE PINE - STREAM MEANDER

These are level lands adjacent to stream courses on the old lake bed around West Yellowstone. The soils differ from those in ELU 23 in that more fine soil particles are present in the soil and it is deeper soil. Lodgepole pine occupies the entire area. There is not a bitterbrush understory.

32. FANS AND TERRACE LANDS

Consists of gently sloping alluvial fans and terraces located between the mountains and the stream courses. Slopes are up to 20 percent. There is no tree cover; grasses and forbs are the dominant vegetation. Soils are moderately deep, of mixed texture with a dark surface horizon rich in humus.

LAND SUITABILITY

After the ecological land units are evaluated, the next step is to determine the suitability of the land for man's uses. Suitability is a term used without regard to time and is based on man's ability to use the land. Restrictions such as economics, desire, and technology are important parameters of suitability.

The following suitability matrix shows how suitable each of the ecological land units is for anticipated activities on those units. These interpretations are based on an interdisciplinary team evaluation.

SUMMARY AND CONCLUSIONS

The objective of this ecological section is to show basic information for which land suitabilities, capabilities, limitations, and natural resource values are determined. These determinations, based on ecological principles, form the basis of making informed land use decisions. A key to the suitability for land use planning is Table 14 entitled, "Hebgen Lake Unit Suitability Matrix" which indicates areas of highly suitable, suitable with moderate restrictions, poor suitability, and unsuitability for various types of activities including man-made features such as road construction, end of road facilities, resorts, campgrounds, and marinas.

In looking at the matrix, it is indicated that for ELU numbers 2, 5, 6, 8, 14, and 20; they are classified unsuitable for most man-made facilities. A limitation of this matrix for land use planning is that it doesn't specifically cover residential structures, but it would be assumed that they would be the same as developments.

The information presented here, and in the “Geology” and “Soils” was used as the basis of an analysis of the development suitability of six different areas within the Hebgen Lake Zoning District, including the appropriate density of residential development. The analysis areas are outlined on the map on page ??? GET FROM COUNTY. Each analysis area is described in Appendix B. In reading this information, remember that the classification of some soils for conventional on-site sewage disposal has been changed from “slight” to “severe” by the Natural Resources Conservation Service (formerly the Soil Conservation Service). The area of severe limitations on development may be larger than represented here.

Table 14

HEBGEN LAKE UNIT SUITABILITY MATRIX

ELU	Timber Harvest	Road Construction	End of Road Facilities	Resorts	Campgrounds	Marina	Water Sports	Winter Sports	Recreation	Wilderness	Backcountry	Snowmobile	Off-road Vehicle	Cross-country Skiing	Utilities	Forage Domestic Livestock	Max. Water Yield
1	*	*	*	x	x	NA	NA	NA	*	+	+	-	-	-	*	*	x
2	*	*	-	-	-	NA	NA	+	*	+	+	+	-	+	*	*	-
3	NA	*	*	*	*	NA	NA	-	*	+	+	+	-	+	*	*	+
5	NA	*	-	-	-	NA	NA	*	-	+	+	+	-	+	*	*	-
6	NA	-	-	-	-	NA	NA	x	-	+	+	x	-	*	-	-	-
7	NA	*	*	*	*	*	NA	*	*	+	+	+	-	+	*	*	-
8	-	*	-	-	-	-	NA	*	-	+	+	-	-	-	-	-	-
11	*	*	*	*	*	NA	NA	*	*	+	+	*	-	*	*	NA	*
13	*	*	*	*	*	NA	NA	*	*	+	+	*	-	*	*	NA	*
14	NA	*	-	-	-	NA	NA	-	-	+	+	-	-	-	*	NA	-
20	NA	-	-	-	-	NA	NA	-	-	+	+	*	-	*	-	-	*
22	*	*	*	NA	*	NA	NA	+	+	+	+	+	*	+	*	*	*
23	*	*	*	*	*	*	NA	*	*	+	+	*	*	*	*	*	*
24	NA	+	NA	*	*	*	NA	*	*	+	+	*	*	*	*	*	*
25	*	*	*	*	*	NA	NA	*	-	+	+	*	-	*	*	*	*
27	-	-	NA	NA	NA	*	*	NA	-	+	+	*	*	*	*	NA	*
31	*	*	*	*	*	*	+	*	*	+	+	*	*	*	*	*	*
32	NA	*	*	*	*	*	NA	*	*	+	+	*	-	*	*	*	*

\+ Highly Suitable
* Suitable with moderate restrictions
x Poor suitability
\- Unsuitable
NA Not applicable

APPENDIX "A"

(Letters)

JOSEPH W. SABOL-ATTORNEY AND COUNSELOR AT LAW

(406) 587-4536-225 EAST MENDENHAL, BOZEMAN. MONTANA 59715

February 25, 1977

Mr. Rick Mayfield
Rick Mayfield & Associates
P. O. Box 1386 Bozeman, Montana 59715

Re: Hebgen Lake Master Plan

Dear Rick:

I am in receipt of your letter dated February 22, 1977, wherein you request permission to use information researched and published by and for Ski Yellowstone, Inc. On behalf of Ski Yellowstone, Inc.,
feel free to use any of the compiled information available to you.

With best personal regards, I remain,

Very truly yours,

Joseph W. Sabol

bmc

UNITED STATES DEPARTMENT of AGRICULTURE
FOREST SERVICE
Gallatin National Forest
P.O. Box 130
Bozeman, Montana 59715

8200
MAR 30 1977

Mr. Rick Mayfield
P.O. Box 1386
103 Commercial Drive
Bozeman, Montana 59715

Dear Rick:

You are welcome to utilize information from the Hebgen Lake Unit Plan in your planning and zoning ordinance efforts. Your plan to provide proper credit is appreciated.

Please let us know if we can be of further assistance.

Sincerely,

LEWIS E. HAWKES
Forest Supervisor

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
P. 0. Box 1017, Bozeman, MT 587-5271 ext. 4278

March 29, 1977

Rick Mayfield & Associates
P. 0. Box 1386
103 Commercial Drive
Bozeman, MT 59715

Dear Rick:

The resource report completed by my office was prepared for the use of the Hebgen Lake Planning District in developing their comprehensive plan. All information, as presented in this report, may be incorporated as the planning district desires in their comprehensive plan. They are the sole proprietors of this information. The Soil Conservation Service, of course, reserves the right to use any materials that are developed in the Soil Conservation report as maybe needed in meeting its responsibilities.

If I can be of any further assistance to you on the matter, please let me know.

Sincerely,

Walter C. Anderson
District Conservationist

APPENDIX B - ANALYSIS AREAS

These analysis areas which are based on information presented in the “Soils” and “Ecological Evaluations” chapters, provided the basis for the density limitations adopted in the original Hebgen Lake Zoning Regulations. Note that some areas shown as having slight limitations on the installation of conventional septic systems may have been reclassified. See the “Soils” chapter for an explanation.

Area Number One

Analysis Area Number One is in the Kirkwood area which is the northwest portion of the zoning district. It is near the Hebgen Lake Dam and is surrounded by public land and Hebgen Lake.

A. Land Use. There are currently two subdivisions in the area and some commercial establishments associated with those developments.

B. Soil Limitations

1. Excavations - There are only slight limitations for most of the area, however, there is an area of severe limitations in the north part of the private land. There are also some moderate and severe limitations in the center of the area.

2. Dwellings with Basements - Most of the area is categorized as having moderate limitations with some severe limitations on the north most portion of the private property.

3. Dwellings without Basements - Limitations follow about the same pattern as indicated for dwellings with basements.

4. Septic Disposal Systems - The limitations for septic disposal systems are generally moderate. However, there are some severe limitations on the north edge of.the private property as well as in the west central section.

5. Local Roads and Streets - Limitations follow the same pattern as in the other three categories with moderate limitations shown.for most of the area and some severe areas on the north edge and within the west central area of the property.

C. Ecological Land Units

1. Developments- Most of the private land within this analysis area is suitable for developments, with restrictions.

2. Roads - The area is indicated as suitable for road construction, with restrictions.

D. Topography-Slope - Most of the private land within this analysis area has very little slope limitations. The north and east edge of the area is over 30 percent slope, but most of this area is outside of the private land.

E. Vegetative Cover - The vegetative cover generally follows the same pattern as the 30 percent slope area designated on the, topography map. Tree cover is generally outside of the private land area.

F. Wildlife - The analysis area contains key winter big game ranges for elk.

There are approximately 100 acres of undeveloped private land within Analysis Area Number One (note: check & update amount of undeveloped acres for each analysis area along with those that have conservation easements on them), most with moderate limitations on development. It is felt the area should have a density of one unit per five acres, unless developed using an open space development approach that recognizes and avoids environmental limitations. Serious consideration of the elk winter range should also be given. Existing commercial uses should be permitted to expand, but within the area presently zoned commercial. Shore line development should only be allowed under sound environmental protection .

Area Number Two

Analysis Area Number Two is in the Watkins Creek area on the south shore of Hebgen Lake.

A. Land Use -- Much of the Watkins Creek area is presently being used for agriculture. There is, however, some summer home development with the area.

B. Soil Limitations

1. Excavations - Most of the private land within the Watkins Creek area is designated as having severe limitations. There is, however, some area of slight limitation in the northeast corner.

2. Dwellings with basements - Limitations for dwellings with basements in the Watkins Creek area are generally slight with some severe limitations along the Ruof ditch.

3. Dwellings without basements - The area is designated as having slight limitations with moderate limitations listed along the Ruof ditch.

4. Septic disposal systems - The area is classified as having slight limitations for most of the land, however, in the northwest corner there are some moderate and severe limitations listed.

5. Local roads - The area is generally designated as having moderate limitations.

C. Ecological Land Units

1. Developments - The area is suitable for resorts with some restrictions.

2. Roads - Most of the area is suitable for road construction with the exception of northwest corner and a portion of the south part of the analysis area.

D. Topography-Slope - The topography of the Watkins Creek area is generally conducive to human activities. There is only one area indicated having a slope of 20 to 30 percent and that is basically on National Forest land.

E. Vegetative Cover - The only woods and brush indicated on the vegetative cover map is generally on forest land.

F. Wildlife - The Watkins Creek area is used by elk for spring calving, sandhill cranes, redtail hawks, and there are also bald eagle nesting areas in the south portion of the district.

This analysis area contains approximately 698 acres of undeveloped land that generally has slight to moderate limitations for human activities. However, there is one factor that precludes most development in the area. That is access. The area is served by one main road going through the National Forest. Any major development would require improvement of that road to county standards with approval of the Forest Service. Until this is done, the area should develop on a basis of one unit per 10 acres. Any major development of the area should also take into consideration the physical limitations along the Ruof ditch and the possible use of the area by bald eagles. Shore line development should only be allowed under strong environmental control.

Area Number Three

Analysis Area Number Three is in the Dave Johnson Creek area on the north shore of Hebgen Lake.

A. Land Use: Most of the area is already subdivided and there are commercial activities within the analysis area in three different locations.

B. Soil Limitations

1. Excavations - Limitations are severe in the entire analysis area.

2. Dwellings with basements - Limitations are slight in the entire analysis area.

3. Dwellings without basements - Limitations are slight.

4. Septic disposal systems - The limitations are generally moderate on those areas that are already subdivided and slight on the areas within the district that are not subdivided.

5. Local roads - The area is classified as having moderate limitations.

C. Ecological Land Units

1. Developments - The private land within the analysis area is designated as being suitable for developments, with restrictions.

2. Roads - The area is designated as being suitable for road construction, with restrictions.

D. Topography-Slope - This analysis area has some limitations because of excessive gradient. Most of the steep slopes, however, are on public land. There are some areas of private undeveloped land that could be classified as over 30 percent and some that have 20 to 30 percent slopes.

E. Vegetative Cover - The vegetative cover of woods and brush follow the steeper slopes and is generally on public land. There is, however, a small amount of vegetative cover on the undeveloped private land.

F. Wildlife - The Dave Johnson Creek area is a key winter range for elk.

There are approximately only 50 acres of undeveloped private land within the analysis area and that is basically surrounded by subdivided property. Limitations are generally slight and on this basis it is recommended that, if developed, the area be developed on the basis of one unit per five acres as a matter of right. Any open space development should take into consideration the steeper slopes on the east area of private land as well as making provisions for preserving the vegetative cover in that area. Also, there should be a thorough study of geological limitations. Commercial establishments should be allowed to expand within the area presently zoned commercial. Shoreline development should only be allowed under strong environmental control.

Area Number Four

Analysis Area Number Four is the Red Canyon area.

A. Land Use - At the present time the area is mostly undeveloped and used for agriculture. There is one major developed area in the west portion of the area: the Yellowstone Holiday subdivision.

B. Soil Limitations

1. Excavation - Limitations are almost entirely severe for the area with the exception of one small area of moderate limitation in the northeast corner of the private property.

2. Dwellings with Basements - Almost the entire area has moderate limitations, with some severe limitations on the northern boundaries of the private property.

3. Dwellings without Basements - Limitations are the same pattern as limitations on dwellings with basements.

4. Septic Disposal Systems - Almost the entire area has severe limitations for development of septic disposal systems.

5. Local Roads and Streets - Most of the area is categorized as having moderate limitations. There are some areas of severe limitations.

C. Ecological Land Units

1. Developments- Most of the area of private land within the Red Canyon area is categorized as suitable for resorts, with some restrictions. There is some area in the eastern portion of the district that is categorized as not suitable for developments.

2. Roads - Almost the entire area is designated as being suitable, with restrictions.

D. Topography-Slope - There is quite a bit of area in the Red Canyon analysis area that is designated as having slopes from 20 to 30 percent and some area, mostly on public lands, of slopes over 30 percent.

E. Vegetative Cover - The vegetative cover of woods and brush follows a pattern corresponding to that of slopes over 20 percent.

F. Wildlife - Portions of the analysis area are designated as key winter ranges for elk and also for use areas by sandhill cranes and Canada geese.

There are approximately 1,000 acres of undeveloped land within this analysis area. It is felt with the severity of limitations for such things as septic disposal systems, that development should occur as a matter of right with a density of one unit per 20 acres. Planned unit developments can be allowed only be allowed upon completion of satisfactory environmental studies and planning which takes into consideration the limitations of the area. Shoreline development should only be allowed under strong environmental control.

Area Number Five

Analysis Area Number Five is in the Horse Butte area on the south shore of the Grayling Arm.

A. Land Use - There are a number of small tracts in the area and some subdivision activity has taken place. The area consists of mostly summer homes, with a few permanent residences.

B. Soil Limitations

1. Excavations - The area near Hebgen Lake is categorized as severe. The middle of the district is categorized as having moderate limitations for development.

2. Dwellings with Basements - The pattern of severity for dwellings with basements follows primarily that same pattern that is outlined in limitations for excavation.

3. Dwellings without Basements - The same pattern is followed here that is followed .in the previous two areas of development.

4. Septic Disposal Systems - Again we have almost the same pattern as for the previous limitations. However, there is slight limitation on the fringes to the east of the private land. The area closest to the Grayling Arm has severe limitations with moderate limitations in the center of the area.

5. Local Roads - The area ranges from severe to moderate.

C. Ecological Land Units

1. Developments- Most of the area is designated as suitable, with restrictions, however, near the shores of Grayling Arm there is an area that is not suitable for development.

2. Roads and streets- Again, most of the area is designated as suitable with restrictions with that area closest to the Grayling Arm being designated as non-suitable.

D. Topography - Slope There is only a small portion of the analysis area that ranges in slope from 20 to 30 percent. Most of that is outside of the private land.

E. Vegetative Cover - There is some area designated as woods and brush on the vegetative cover map, however, most of that is outside of the private land.

F. Wildlife - There is a large area within the Horse Butte area that is designated as use area for sandhill cranes and nesting for Canadian geese. There are also waterfowl breeding areas near the shore of Hebgen Lake.

There is approximately 700 acres of undeveloped land in the Horse Butte area. Because of the severe limitations found in the area, most of it should be designated as one unit per 10 acres. Open space development that recognizes environmental limitations could also be appropriate. Shore line development should only be allowed under strong environmental controls and some consideration should be given to the waterfowl habitat. Commercial development should be prohibited.

Area Number Six

Analysis Area Number Six is on the east shore of Grayling Arm, extending to the boundary of Yellowstone National Park. It encompasses the area of Grayling Creek and Duck Creek.

A. Land Use - The land use is either subdivided or agricultural land with some commercial development.

B. Soil Limitations

1. Excavations - Most of the private land in this section is categorized as having severe limitations, with the exception of some slight to moderate limitations in the northeast portion of the district.

2. Dwellings with basements - The center of the analysis area is categorized as having slight limitations. In the northeast section there is an area of slight to moderate limitation and on the fringe areas along the lake and along Grayling and Cougar Creeks there are areas of severe limitations.

3. Dwellings without basements - Limitations are generally the same as on dwellings with basements.

4. Septic disposal systems - The center of the analysis area has slight limitations. The northeast corner has moderate limitations. The areas along the creeks and Grayling Arm have severe limitations.

5. Local roads - Almost the entire area is categorized as having moderate limitations with the exception of severe limitations along the creeks and Grayling Arm.

C. Ecological Land Units

1. Developments - Most of the district is categorized as being suitable with some restrictions. The exceptions are those areas along Grayling, Duck, and Cougar Creeks that are not suitable for developments.

2. Roads - The center of the area is suitable for road construction. The east section is categorized as suitable with some restrictions. Areas along the creek bottoms are categorized as not suitable.

D. Topography - Slope- There are no topographic limitations for development in this district.

E. Vegetative Cover - There is some tree cover on the outer edges of the area, especially in the north portion of the analysis area. There are areas of wetlands along the creek bottom.

F. Wildlife.- There are areas designated as winter ranges for elk and moose. The moose range is generally along the creek bottoms in the willow areas and primarily public land. Also there are areas designated as Canadian geese nesting sites and sandhill crane use areas as well as potential d for waterfowl breeding.

This is the largest of the six analysis areas, including approximately 750 acres of undeveloped land. Most of the land has good access to major highways. The area currently has some summer home and permanent residences. Continued development could be considered depending upon the severity of limitations on development of the property ranging from one unit per five acres to one unit per 10 acres. Open space development could be used to avoid severe limitations, including soils and geology. Wetlands and creek bottom areas should be protected as well as the shores of Hebgen Lake. Shore line development should only be allowed under strong environmental control.